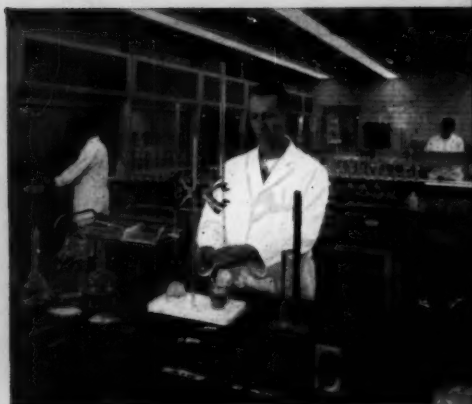


AUGUST 1960

modern castings



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KNOWN CHEMICAL PROPERTIES. Every melt of Olin Aluminum undergoes exacting metallurgical and production controls.



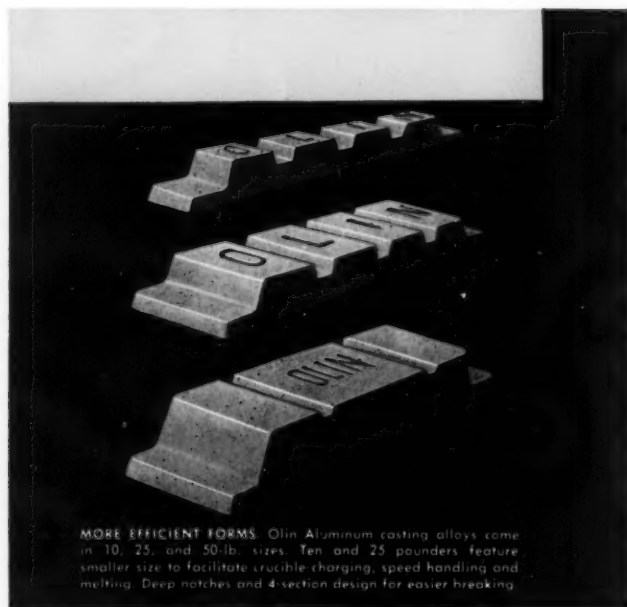
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Remember, Olin Aluminum doesn't sell castings; we simply want to help you to produce better castings. For quality, service and dependability — call your Olin Aluminum office or distributor.

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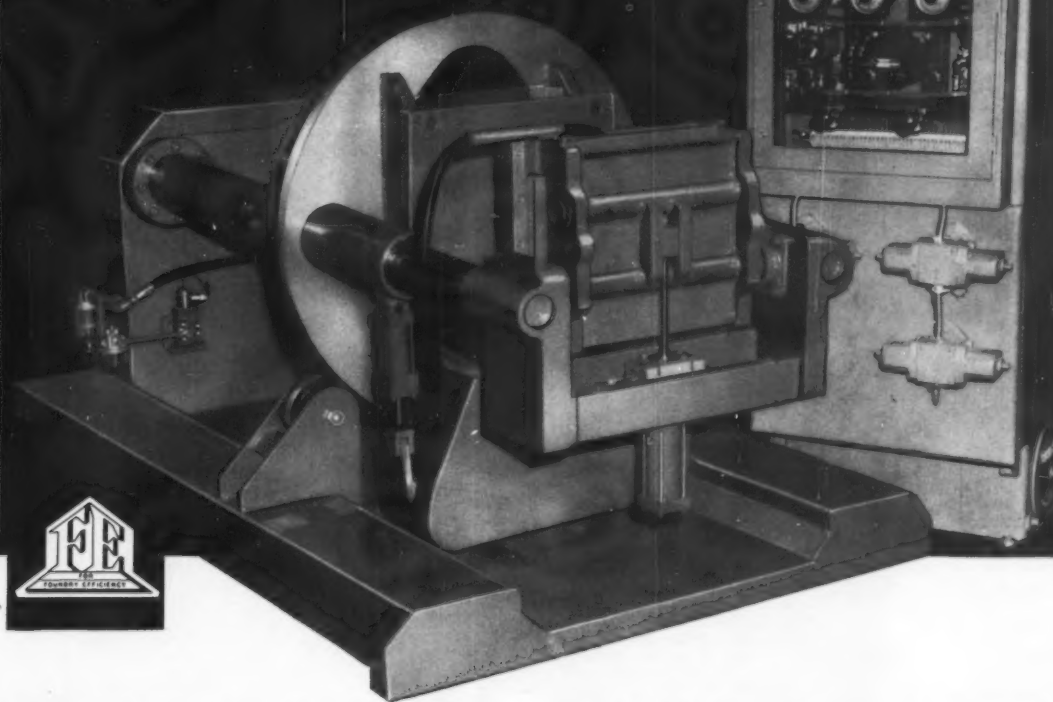


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POWER CONSUMPTION: 20"x16" heater plate, 16½ KW — 20"x24" plate, 24 KW.

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F. E.'s new, streamlined Shell Core Blower uses two standard size, interchangeable heater plates — 20"x16" for core box sizes up to 20"x17"x14", and 20"x24" for boxes to 20"x25"x14".

All movements hydraulically controlled. Hydraulic unit and electric control panel self-contained, placed for convenience. Cores are ejected by means of a "flip-plate" assembly, which virtually "hands" cores to the operator. At no time does the operator have his hands between the heater plates.

F. E.'s Shell Core Blower is fast, efficient and very easy to operate. Turns out perfect shell cores — no core breakage, no core box wear. Quickly changed from fully-automatic to single cycle control. Easily set up and economical to operate.

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Circle No. 137, Page 151

August 1960 1



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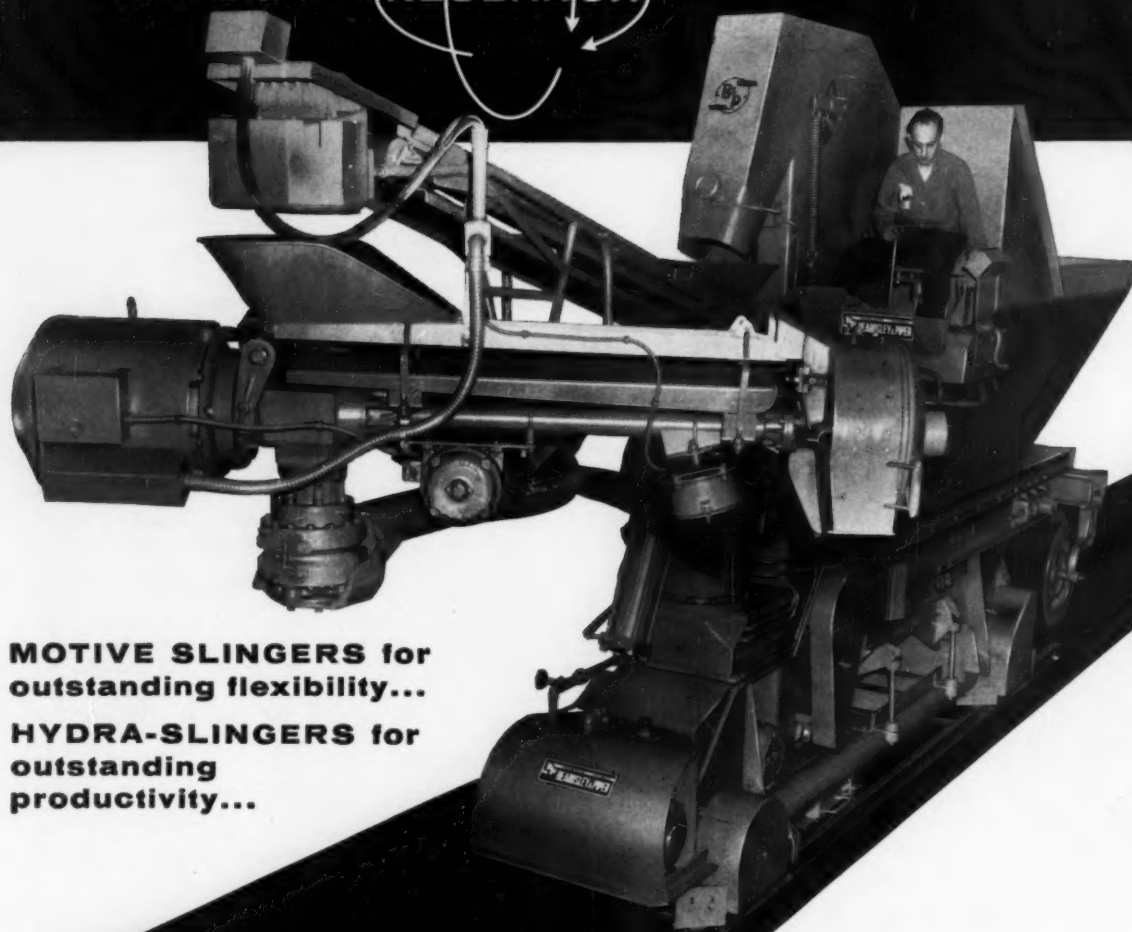
MODERN CASTINGS is indexed by Engineering Index, Inc., 29 West 39th St., New York 18, N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich. The American Foundrymen's Society is not re-

sponsible for statements or opinions advanced by authors of papers or articles printed in its publication. Published monthly by the American Foundrymen's Society, Inc., Golf & Wolf Roads, Des

Plaines, Ill. Subscription price in the U.S., \$5.00 per year; elsewhere, \$7.50. Single copies 50¢. April, May and June issues \$1.00. Entered as second-class mail at Pontiac, Ill. Additional entry at Des Plaines, Ill.

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Circle No. 136, Page 151

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GENERAL MANAGER

WM. W. MALONEY

Let's look at...

MOVING QUICKLY NOW!

A TIMELY series begins this month in MODERN CASTINGS. Experts in various industries served by metalcasting tell you what they want from you in products and services. In this issue the authorities are from the materials handling industry, (See page 31.) Giving substance to their ideas and suggestions is still another article, "Stacker Cranes Link Melting, Molding, and Shake-out." (Page 40.)

These articles are important because they ask you to grow faster, to think faster. And there's another aspect: the not too subtle implication that some industry other than metalcasting may win out if you don't. That means a lost market, or one in which metalcasting becomes less and less important.

You and I know that a great technological revolution is taking place in metalcasting. We know there is a tremendous thirst for new ideas, processes, and techniques. MODERN CASTINGS presents 110 to 130 pages of editorial material each month on these phases, most of it exclusive and devoted to the urgent demands of a changing industry.

There is an urgency about this change which must be recognized. You can get an idea from the news story on page 121 of this issue. News Editor George Mott reports on business trends and expansion plans in metalcasting.

Here again is a typical example of the leadership thinking and progress reported in your magazine, MODERN CASTINGS, every month in the year. Only in MODERN CASTINGS do you get such a significant and exclusive combination of industry leadership, management thinking, and technological data.



G. A. Mott

2 PAYLOADER® units...



Lancaster's two H-25's windrow and mix sand on pouring floor — carry and feed to the separator — feed the muller—return sand to 58 molding stations — carry slag to dump — unload boxcars of sand.



...speed sand handling at Lancaster Malleable Castings Company

This Lancaster, Pa., foundry has been a "PAYLOADER" booster ever since its first one, a Model HA, went to work in 1948. Since January 1959, two of the new H-25 Models have been placed in operation. Says Clarence Hess, Foreman, "Our first H-25 had worked some 2,200 hours before we added the second one. We find these H-25's have twice the production of old HA's. They are much easier on the operator and give all-around efficient operation, because of their faster load delivery cycle and greater carrying capacity. They have outstanding maneuverability."

At Lancaster Malleable the night shift uses the H-25's to handle about 90 tons of sand four times during separate stages of stockpiling, mixing, feeding the separator and transporting sand to the 58 molding stations. The day shift uses one machine to handle slag and unload boxcars of sand.

Foundries and plants of all kinds have found that the Model H-25 is the answer for more efficient indoor bulk handling. Interchangeable attachments are also available for special jobs: sweeper, fork lift, hydraulic grab, crane hook. Write for complete data.

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Around the World with Modern Castings



SWITZERLAND

Zurich is the setting for the 27th International Foundry Congress, Sept. 19-24. Twenty-four official exchange papers from 18 countries are scheduled for presentation. The complete list appears on page 131. Here's a wonderful opportunity to visit Switzerland, exchange ideas with foundrymen from all over the world, and visit a number of progressive European foundries.

RUSSIA

Something new—two-layer shells for shell molding! The inner silica shell is only 0.04 to 0.08 inches thick but uses 8 per cent phenolic binder. Outer shell is 0.16 to 0.40 inches thick, uses only 3 per cent binder. This is one way to get the maximum strength next to the casting and still economize on resin costs.

ITALY

Die casting machine operators don't have to stand idle while waiting for castings to be made. At the Necchi Works in Pavia, Buhler horizontal cold-chamber die casting machines have automatic molten metal ladling. Operator only pushes button to initiate casting cycle and later remove casting from open die. During the interim he knocks off the biscuit, runner system, and overflow wells; removes knockout cores; and inspects casting for flaws. Now these operations don't have to be performed in the cleaning room, and the machine operator makes more productive use of his dwell time.

SWEDEN

Steel die casting dies have been given a new lease on life expectancy by nitriding or a Sulfinuz treatment. The latter does not increase sensitivity of steel to heat checking. Both treatments increase die resistance to soldering and erosion by molten aluminum.

UNITED STATES

Scrap aluminum exports have jumped almost 400 per cent! Compared with first four months of 1959 this increase in 1960 represents a "serious drain of strategic materials, posing a threat to domestic industry," according to C. H. Burton, secretary of the Aluminum Smelters Research Institute. In April the export figure reached 16.3 million pounds. Exports for 1960 could reach as high as 150 million pounds—15 per cent of our expected total aluminum scrap supply. The Department of Commerce has been asked to monitor this overseas tonnage flow. The National Association of Secondary Material Industries, Inc. claims there is a surplus of domestic aluminum scrap and the export business is vitally necessary for the economic health of a large segment of our scrap metal industry. Viewpoint seems to depend on whether you are buying or selling aluminum scrap.

JAPAN

If you want high quality gray iron castings with uniformly fine type-A graphite, then use medium-sized coke. An extensive study at Waseda University showed that large coke caused severe oxidizing conditions, high coke consumption, high tapping temperature, high CO₂ gas content in cupola, higher FeO and SiO₂ in slag, good carbon

Around the World . . .

pickup, increased fluidity, increased type D graphite. Small-sized coke concentrates combustion in lower part of cupola so tapping temperature is low, CO₂ content is low, oxidation effects are small, and metal has poor fluidity. The medium-sized coke displayed the optimum conditions for quality gray iron.

ENGLAND

New foundry of Austin Hopkinson & Co., Ltd., Audenshaw, North Wales, England shows the signs of modern times. All melting of iron and steel for mining equipment castings is done in two mains-frequency coreless induction-melting furnaces. Each furnace has nominal capacity of 3000 pounds. Also unique was the decision to make all molds and cores by the CO₂ process. So sand preparation, handling, and molding, as well as patterns and core boxes, are designed specifically to the requirements of the CO₂ process. **The decision to use electric induction melting and sodium silicate bonded sand was based on a desire to produce quality castings with relatively unskilled foundry help.**

RUSSIA

Basic molding materials—chromite and chrome magnesite—show the least wetting by any composition of steel. They are receiving wide usage in Russia for refractory washes and mold facings.

WESTERN EUROPE

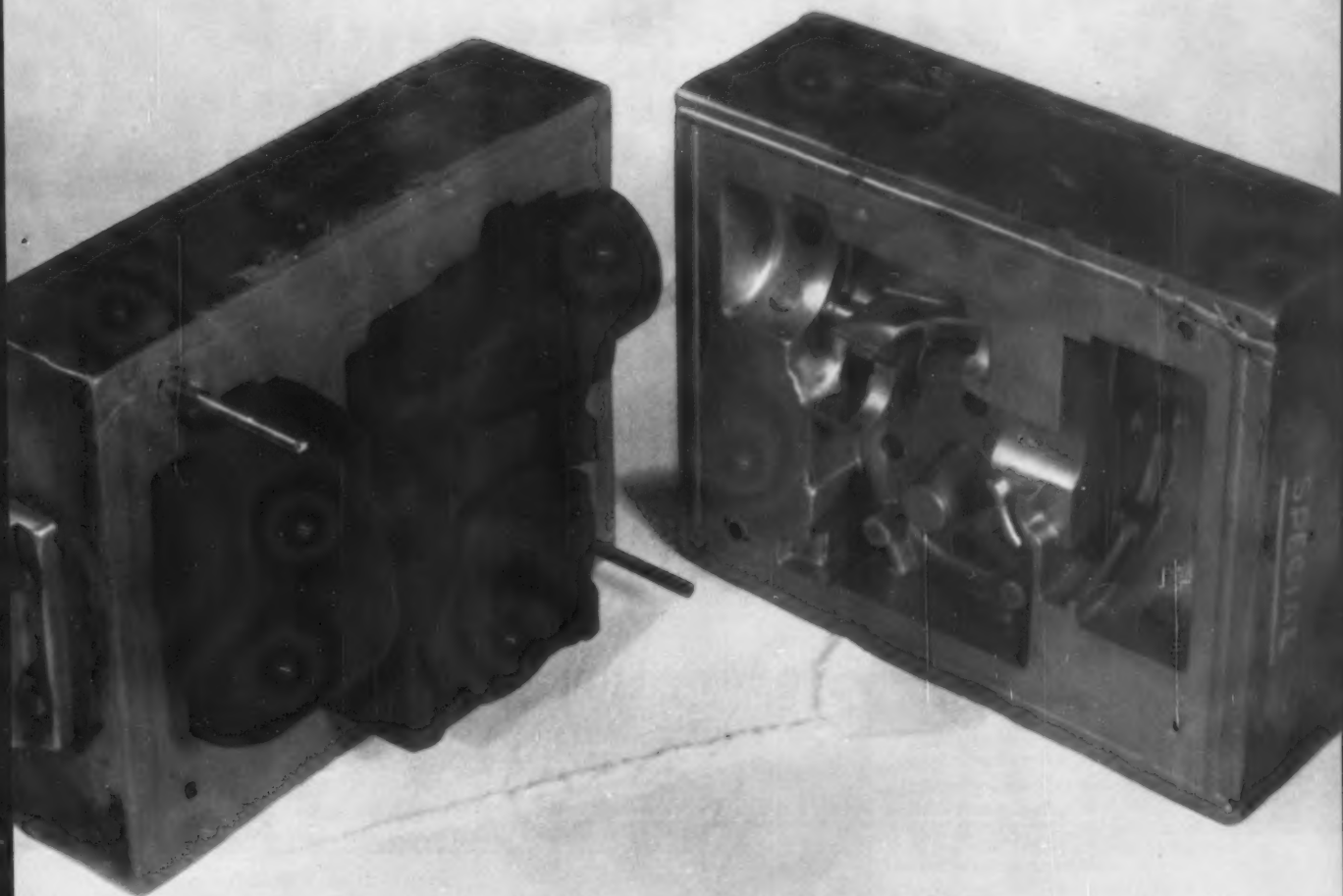
The third European Foundry Apprentice competition was held in May of this year at the National Foundry College, Wolverhampton, and the foundry of F. H. Lloyd & Co. Ltd., Wednesbury, England. **Seventeen young foundrymen, representing 25,000 apprentices in United Kingdom, France, Germany, Denmark, Holland, Italy, Austria, and Sweden, competed four days.** Written tests on foundry technology were followed by two days of practical skill tests in molding and casting a sizeable engineering component of considerable complexity.

France placed first with Great Britain a close second. Prizes and trophies were awarded highest scoring individuals and teams by the Parliamentary secretary to the Ministry of Labor. This international contest is sponsored by the European Committee of Foundry Associations. It offers a wonderful opportunity for the foundry industry to show off its talented young men and bring them together in friendly rivalry.

GERMANY

In an exclusive MODERN CASTINGS interview, A. Wittmoser, Director of Research & Development, Rheinische Stahlwerke, Gelsenkirchen, Germany, told about casting gray iron and ductile iron continuously in water-cooled copper molds. Diameters range from 23.5 inches to 5 feet; wall thicknesses are 0.47 inches to 0.79 inches; and lengths up to 33 feet! Same continuous technique is used to make cylinder liners for marine engines and piston rings. Rapid metal cooling effected by water-cooled copper mold and core produces fine-grained pearlite and graphite. This structure demonstrates superior corrosion and wear resistance in service.





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VOLCLAY BENTONITE

.....**NEWSLETTER No. 69**.....

REPORTING NEWS AND DEVELOPMENTS IN THE FOUNDRY USE OF BENTONITE

"IS GREEN COMPRESSION STRENGTH ENOUGH?"

Selling to the foundry market is a difficult job. The buyer of a product is exposed to a great mass of appeals for his business. He may not respond to general claims that have little specific meaning.

In a few isolated cases, claims have been made that a western bentonite may possess higher green compression strength than the accepted normal.

If green compression strength were the sole evaluation, there would be little western bentonite sold to the foundry industry. Southern bentonite would enjoy the market and western bentonite would be used sparingly.

A buyer of western bentonite wants to deal with people who are concerned with his problems. For this reason, Colloid's lab has determined years ago that a western bentonite with unusually high green strength generally sacrifices other properties such as having lower dry strength, lower hot strength, lower deformation, lower toughness and a lesser range of holding temper water.

If a western bentonite loses dry and hot properties by sacrificing them for green compression strength, the value of it being used as a western bentonite is lost!

Do not judge a western bentonite solely on one property! The complete range of properties must be studied to meet a foundry's needs.

VOLCLAY is a western bentonite that has been time-tested by the foundry industry for high quality. This is maintained by constant vigil.



"Adding that Volclay sure gives a grasping power to the sand."

**DO YOU HAVE "ECONOMY IN THE FOUNDRY"?
WRITE FOR BULLETIN NO. 243**

AMERICAN COLLOID COMPANY

SKOKIE, ILLINOIS • PRODUCERS OF VOLCLAY AND PANTHER CREEK BENTONITE

Reader Opinions and Ideas...

Promote Gray Iron

We feel the future for gray iron, ductile iron, and allied alloys will grow rather than decline in the next ten years.

We have wondered why the pig iron industry has not taken a stronger stand against certain claims as made by ingot aluminum producers. A defense is not as good as an offense, and we have been concerned about the "satisfied interest" that seems to be associated with the gray iron industry. So much advancement is being done in the foundry industry at this date which will effect all of our lives in the next twenty-five years or sooner.

The gray iron casting industry should work to promote gray iron sand casting products, as economy is in their favor. A fantastic market will develop if we simply do better with what we have than to attempt to put into production claims that have yet to be time-tested or proven.

C. A. SANDERS
Vice President
American Colloid Co.
Skokie, Ill.

Wants Reprints

We have just read, with a great deal of interest, Mr. C. A. Sanders' article "Gray Iron vs Aluminum" and feel the article presents a strong argument for the use of gray iron. We would like to distribute a number of these articles to our friends in industry and would appreciate your quoting us on 1000 reprints.

If reprints are not available, please advise us if we might have permission to have the article copied?

H. H. MACLER, President
The Drake Manufacturing Co.
Friendship, N. Y.

To Have Contest

I have read your article on "Gray Iron vs. Aluminum" in the June issue of MODERN CASTINGS, and I thank you for the encouragement you have given me as a producer of pig iron. It may also be that the pig iron industry has not pushed their product as much as they should have in the past. We, at Hanna, are going forward with an advertising campaign, an award for design of gray iron cast-

Continued on page 14

**ARE YOU
ADDING
WATER
TO YOUR
SAND
manually?**



*eliminate the guess
work with the new
DIETERT-DETROIT
MILL MOISTMETER*

SHOWS moisture content of sand in muller throughout mixing cycle.

ELIMINATES guess-work at sand-preparing station.

REDUCES casting losses through uniform moisture control.

INCREASES mold production by supplying uniform sand to molding stations.



Dietert-Detroit No. 3901 Mill Moistmeter

1. Indicates moisture of sand in mill before discharge. Gives operator constant control for proper water addition.
2. Indicates temperature of sand batches. This shows operator when to add extra water to allow for evaporation from hot batches.
3. Low cost unit provides maximum moisture control for uniform sand batches.
4. Compact, rugged case requires small space. Can be conveniently placed anywhere for maximum operator efficiency.
5. Easy-to-read illuminated meter dials.
6. 6" moisture scale has large indicator hand for greater visibility.
7. Simple, trouble-free circuitry contains no timers, relays or vacuum tubes.
8. Quick representative sampling is assured by a durable metal sensing probe and thermocouple placed in the mixer.
9. Optional RECORDER provides permanent record of moisture content in each batch of sand. This compact remote recorder can be used anywhere. Placed in superintendent's office, unit gives exact moisture content at a glance without going out into foundry.

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Gentlemen:

Send me facts on the new Dietert-Detroit No. 3901 Mill-Moistmeter.

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Circle No. 140, Page 151



The sand in the microphoto above speaks quality. It's pure and fine, with the excellent rounded grain properties so desired for foundry use. This is indeed a superb sand—finest for foundries.

The obvious merits of quality can be yours with Wedron Silica

 <p>MINES AND MILLS IN THE OTTAWA-WEDRON DISTRICT</p> <p>WEDRON SILICA COMPANY</p> <p>135 S. LaSalle St., Chicago 3, Ill.</p>	<p>for glass for ceramics</p> 
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Circle No. 141, Page 151

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④ **Global Ore Sources** assure you uninterrupted supplies of ferroalloys. UCM's close association with world-wide mines provides dependable raw material sources.

⑤ **Strictest Quality Control**—with over 100,000 tests per month from mines to shipment—makes sure you always get alloys of uniform size and analysis, with minimum fines, lot after lot.

For better metals, production economies, bigger profits, insist on UCM's FIVE-DEEP alloys. Union Carbide Metals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y., producer of "Electromet" brand metallurgical products.

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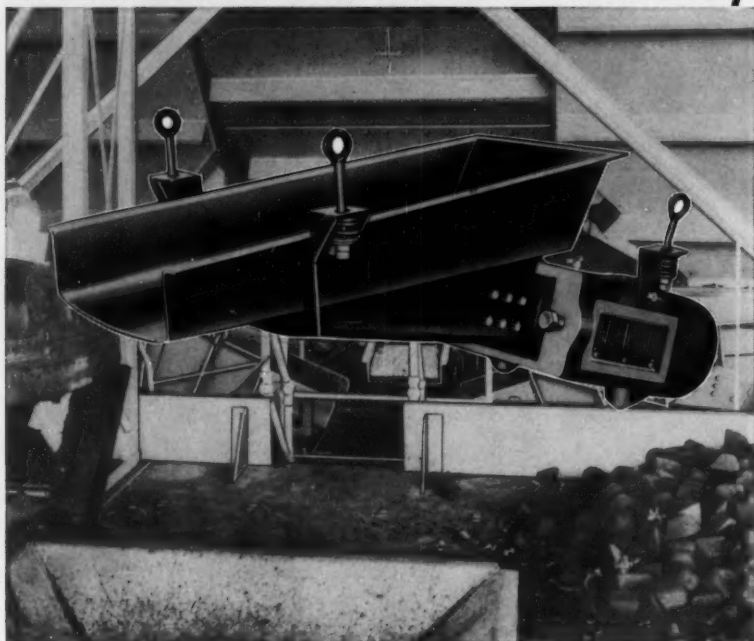
METALS

Only **ELECTROMET** ferroalloys from **UCM** are so deep in extra values to help you.

Circle No. 142, Page 151

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moves bulk material more efficiently



SYNTRON *Vibra-Flow*

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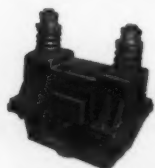
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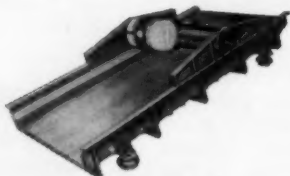
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TEST SIEVE SHAKERS

Circle No. 143, Page 151

Reader Opinions . .

Continued from page 11

ings to supplant other metals or method of manufacture, and cooperation with foundrymen to improve quality and/or structure of their product.

A. J. MACDONALD

President

The Hanna Furnace Corp.
Buffalo, N. Y.

More Reprints

We read with great interest your article entitled "Gray Iron vs. Aluminum" which appeared in the June issue of MODERN CASTINGS. We would appreciate it if you would be kind enough to arrange to have some 150 copies printed and forwarded to us. At the same time advise us of your cost so that we may reimburse you.

W. H. WEISE,

Works Metallurgist

American Steel & Wire Div.

United States Steel Corp.

Cleveland

A Master Advocate

Your article in the current issue of MODERN CASTINGS concerning the exposure of claims for the all aluminum engine, was, to put it mildly, magnificent!

I enjoyed every word of it, being of course, slightly prejudiced. I passed it around to all who were most in need of such a reminder. You have indeed proved a master advocate for all whose bread and butter depends on one form or another of cast iron. We all owe you a debt of gratitude.

HAROLD E. HENDERSON

Berkeley, Calif.

Timely Article

I read your article in MODERN CASTINGS on "Gray Iron vs. Aluminum". In my opinion it is an excellent article and brings to the front a timely subject. We need more like it.

E. C. ZIRZOW,

Director of Foundry Service

Werner G. Smith, Inc.

Cleveland

More Bonuses

We are interested in securing four additional copies of the 16-page special bonus section on Heat Treating for the Modern Malleable Iron Foundry.

W. H. MACLEAN

Galt Malleable Iron Ltd.

Galt, Ontario



...get fast delivery on any aluminum alloy pig or ingot from your REYNOLDS INGOT DISTRIBUTOR

The old cliché, "time is money" really hits home when your casting operation is held up for want of metal. But if that metal is aluminum, there's no problem. Just call your local Reynolds Ingot Distributor.

Chances are, the metal you need—in the right alloy and size will be at your doorstep in 24 hours or less from your Reynolds Dis-

tributor's stock. Or he can get you any casting alloy for prompt shipment from Reynolds plant inventory.

Your Reynolds Ingot Distributor is geared to deliver the pig and ingot you need *fast*. Call him.

Reynolds Metals Company, P.O. Box 2346-FL, Richmond 18, Virginia.

REYNOLDS INGOT DISTRIBUTORS

Abasco, Incorporated, P. O. Box 13367, Dallas 20, Texas • American Alloys Corp., 4446 Belleview, Kansas City, Mo.
Atlas Metal Co., 8550 Aetna Road, Cleveland 4, Ohio • Barth Smelting Corp., 99-129 Chapel Street, Newark, N. J.
Bay State Refining Co., 8 Montgomery Street, Chicopee Falls, Mass. • W. F. Jobbins, Inc., North Lake Street Rd., Aurora, Ill.
Morris P. Kirk & Son, Inc., 2700 S. Indiana St., Los Angeles, Calif. • Milward Alloys, Inc., Lockport, N. Y.
Milwaukee Chaplet and Supply Corp., 8656 W. National Ave., Milwaukee, Wis. • Richards Corp., 356 Commercial St., Malden, Mass.
Sipl Metals Co., 1720 N. Elston Ave., Chicago 22, Ill. • Sonken-Galamba Corporation, 2nd and Riverview, Kansas City, Kansas
Nathan Trotter & Co., 36 N. Front Street, Philadelphia 6, Pa.

REYNOLDS ALUMINUM

Watch Reynolds TV Shows: "Bourbon Street Beat" and "Adventures in Paradise"; and, resuming in October, "All Star Golf"—ABC-TV





Can you store cores in stacks like this?

You can if they're *shell cores*.

That's only *one* of the bonus features shell coring gave Buffalo Pipe and Foundry Company. Others:

Fourteen men turn out 4,000 soil pipe fittings daily . . . in 225 different designs. Previously it would have required fifty men to produce the same

quantity. These castings are better, too. Weight can be controlled better. Harder, smoother core surfaces give the fittings a better internal surface. There's less scrap.

Much of the credit goes to Milton Emery, the foundry's production manager, who could see the real ad-

vantages of shell cores. Working closely with the Durez technical staff, Mr. Emery was able to perfect his process, using a Durez liquid resin.

If you'd like to enjoy the many advantages of shell cores, get in touch with Durez at 8908 Walck Road, North Tonawanda, N. Y.

DUREZ PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION, 8908 WALCK RD., NORTH TONAWANDA, N. Y.



Circle No. 145, Page 151

THE GRAPEVINE

by H. F. DIETRICH



Every shop—and every office too—has a most efficient news disseminating agency. It would seem that even the walls have ears. Anything mentioned aloud, whispered, or even thought about in a closed office is immediately the property of the working public. By popular definition, this local broadcasting network is called *the grapevine*.

As old as man, and as wide spread as human curiosity, the grapevine has become an institution. With its roots in the very foundation of civilization, it has become immune to any method yet tried to curb, muzzle, or stamp out. No wonder every foundry has its built-in rumor mill. Unless this mill is properly fed, it will grind out its own brand of rumor with little regard for the truth. The objective always is a banner headline.

Now, the question is, as long as we have such an efficient news gathering agency, would it be considered dirty pool to use it to influence shop attitude?

Once on the west coast, I saw a plant superintendent play on the grapevine with such dexterity and talent that it reminded one of an artist at work. He could create in the shop personnel all of the moods and attitudes of which the group was capable. With his flare for histrionics, Paul the Super was a true conductor of grapevine orchestration.

The pervasion of news in this foundry was the sole purpose in the life of Leo the gangwayman. He had numerous talents. For one thing, he looked less like a gangwayman than any wheelbarrow pilot I have ever seen in a foundry. With his upright posture, his bow tie, his neatly washed and pressed overalls, and his excellent use of English, it seemed that he would have been more at home as a butler, or a head waiter in some swank restaurant.

Leo also had the ability to travel greater distances with an empty wheelbarrow than any gangwayman I ever knew. Besides this, he had the sharp eyes, the exceptional hearing, the friendly manner, and that

prime requisite, a genuine interest in other peoples' business that is necessary in a past master of gossip.

If approached in the right way, Leo was a goldmine of information. He could tell you the date on which the yardman broke his leg, how many fish Joe caught on the opening day of trout season—last year, and the exact number of men involved in Custer's last stand.

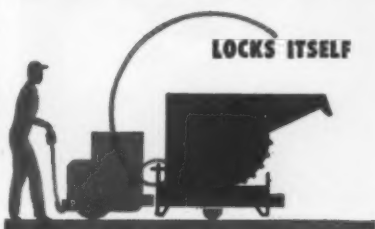
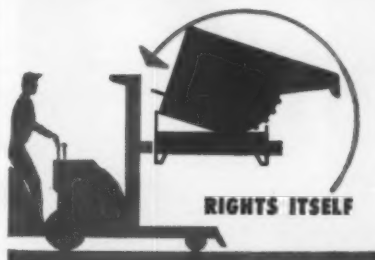
Paul too, had something above the IQ of an idiot. Without seeming to do so, he would listen to what Leo had to say, and then to preserve Leo's reputation, he would feed into this grapevine funnel just enough choice bits of authentic information to keep the mill rolling. In this way he played both ends against the middle.

Every foreman who has ever had anything to do with a work schedule knows that his men are most likely to go fishing when there's lots of work in the shop. It's when the foreman wonders what he is going to do with the full crew the next day that everyone shows up.

When absenteeism became a problem, Paul would feed into the grapevine the information that he didn't know where the next order was coming from. Without fail, the next week was run with a full crew. To make Leo look good, he would put no more on the schedule board than could be handled from day to day.

If the crew became restless with uncertainty about how much longer they would have work, Paul would let it be known that he had contacted old customers and had the promise of more work. Even if the work didn't materialize, the crew knew that Paul was trying to keep the shop open. It was a wonder to behold the dexterity with which he played on the emotions and attitudes of the crew.

Is it dirty pool to use any means at your disposal to keep a shop running smoothly? You can't stamp it out. You can't muzzle it. So you might as well join it and make use of that great human institution, THE GRAPEVINE.



Cuts handling time ...and costs...in half

Here's the fastest, lowest cost method ever devised for handling all kinds of bulk materials . . . hot or cold . . . wet or dry . . . such as:

Punch Press Parts . . . Cinders
Hot Forging or Castings . . . Scrap Metal
Pickles . . . Soybean Meal

A Roura Hopper fits any standard lift truck . . . attached or detached in seconds . . . can't slip off. One man does the entire job. Picks up loaded Hopper with lift truck . . . transports it to destination . . . flips the latch . . . and the Hopper automatically dumps its load, rights itself, locks itself. Cuts costs 50% or more.

Made of $\frac{3}{4}$ " steel plate with continuous arc-welded joints. Heavier plate if desired, also stainless steel or galvanized. Eight sizes from $\frac{1}{2}$ to 4 yards capacity. Fitted with live skids or a choice of wheels. Standard models available for immediate shipment from stock.

ROURA

Self-Dumping

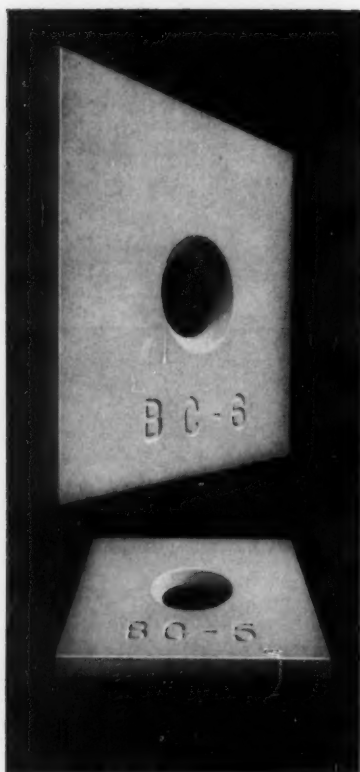
HOPPER

WANT MORE FACTS?

We'll give you full details . . . without obligation . . . if you'll attach this coupon to your letterhead . . . sign your name . . . and mail to . . .

ROURA IRON WORKS, INC.
1414 Woodland Ave., Detroit 11, Michigan

Circle No. 146, Page 131



Louthan breaker cores cut foundry costs

You minimize casting problems, get cleaner castings when you use Louthan *refractory* breaker cores. They facilitate rapid removal of the riser, with subsequent labor savings. There is no core gas. Available for all riser diameters from 2" to 12", and for use with any metal casting rising from a flat surface.



Write for Free Gating and Riser Refractory Folder. Complete file of specifications on all Louthan products.

LOUTHAN
MANUFACTURING COMPANY

A DIVISION OF **FERRO** CORPORATION
EAST LIVERPOOL, OHIO

SAFETY-HYGIENE-AIR POLLUTION

OPHTHALMOLOGIST, OCULIST, OPTOMETRIST, OR OPTICIAN



by HERBERT J. WEBER

Do you know the difference? If not, it is important that you do. The ophthalmologist is a member of the medical profession who specializes in diagnosis and treatment of diseases of the eye; performs surgery on the eye, such as corneal transplants and cataract removal; tests vision and prescribes glasses.

Oculist is another word for ophthalmologist.

The optometrist is not trained to diagnose or treat diseases of the eye. Neither is he permitted to do surgery; but he can test vision and prescribe glasses.

The optician is not any eye expert; rather he is a lens grinder. He specializes in making glasses according to prescription. Don't rely on a "free eye examination" by an optician.

I wonder if many of us realize the awesomeness and complexity of the eye. It takes thousands of pictures; develops and prints them; and presents them to the optic nerve for viewing—and all this in less than a minute. All the more remarkable is the fact that the pictures are taken in three dimension and in color.

What commercial photographer can duplicate these feats?

The eye has a built-in light meter which automatically adjusts the diaphragm of the human camera for the correct amount of light and even makes the proper correction for distance.

This marvelous gift of vision is not properly appreciated until it is lost. We hear of preventive maintenance in the plants but how much preventive maintenance of the eye is practiced?

How often do we go to an ophthalmologist (not an optometrist) for an eye check-up? He is a physician who can detect early glaucoma, cataracts, and the like. Some diseases of the body, other than those of the eye, leave tell-tale signs in the eye which he can spot on examination and then prescribe early treatment for them.

An examination by an eye physician at least every two years is good pre-

ventive maintenance. Another thing to remember! If he or your optometrist prescribes glasses, be sure to request case hardened (safety) lenses. The increase in cost is insignificant and you will have both on-and-off-the-job eye protection.

If you need prescription glasses, wear them, especially at work. Faulty vision and the fatigue from eye strain that goes with it lead to misjudgments and mistakes.

These, in turn, can lead to unnecessary injury. One company in reviewing its safety files found that employees with good safety records usually had good eyesight or wore corrective lenses. On the other hand, 68 per cent of those frequently injured had poor eyesight and did not wear corrective lenses.

When you get in the mid-forties, chances are that you may need bifocal or trifocal lenses. That is a good time to get an eye examination.

The gift of vision is so precious that I believe it borders on the criminal to allow men to work in plants without suitable eye protection. The practice of specifying eye protection for certain foundry jobs while exempting others is pure nonsense.

Let's take the case where the rule requires eye protection for the pouring crew but none for the molders nearby. Suppose you have a freak spatter of metal or mild explosion resulting in hot metal striking the molders' eyes.

The cost of the lost eyesight in a single accident will pay for hundreds of pairs of safety goggles. Eye protection for everyone is good sense and good business.

A foundry plant manager once told me he could not get his men to wear safety goggles. Later, when he took me on a tour of the plant, I noticed that he didn't wear them either. No wonder they didn't!

I call this mental blindness; and if you want to keep this gift of vision, ask a blind man about the darkness. This is the only case where the blind can lead the blind.

From a laboratory furnace to a reverberatory furnace Hevi-Duty helps you find the value solution to your non-ferrous melting problems

Hevi-Duty's value solutions to three melting problems are described below. Such solutions call for comprehensive industrial engineering ability as proved by Hevi-Duty's success in solving thousands of heat processing problems in all types of applications.

Such solutions call for creative design engineering ability backed by Hevi-Duty's experience with industry's most complete line of electric and fuel-fired furnaces and ovens. (Where stock designs or adaptations won't do, Hevi-Duty custom-engineers equipment including huge field-erected furnaces.)

Such solutions call for soundly built and tested equipment typified by Hevi-Duty furnaces now paying off

throughout industry in increased production and extended economic life of equipment.

Case histories by the hundreds testify that it makes profitable sense to call in your Hevi-Duty sales engineer to help find the value solution to your melting problems.

HEVI-DUTY

Electric and Fuel-Fired
Industrial Furnaces and Ovens



A Division of
Basic Products
Corporation

Hevi-Duty Electric Company, Milwaukee 1, Wis.



Hevi-Duty G-05 laboratory furnace used by Great Lakes Steel Corp., Detroit, for determining alumina content of slag is kept at 2200°F, 24 hours a day, 7 days a week. It heats rapidly, has 48 steps of control between 1700°F and 2600°F. Instruments and controls in base remain close to room temperature. For more information please request Bulletin 254.

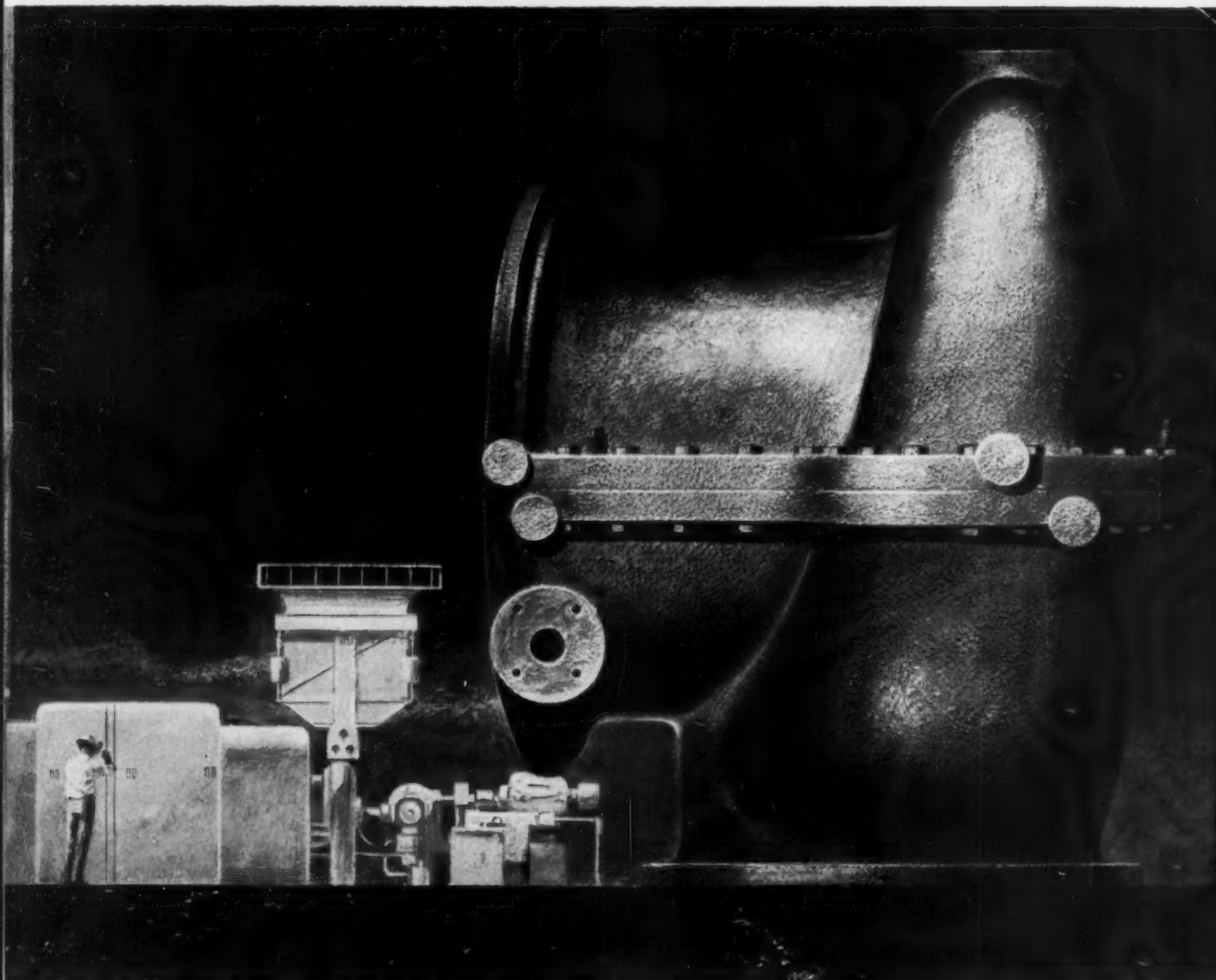


Double-chamber dry-hearth aluminum melting furnace covers only 32 sq. ft. area at In-Sink-Erator Co., Racine, Wis., yet melts and holds up to 400 pounds of aluminum per hour after 2½-hour warm up. Well insulated furnace permits use of a permanent mold machine next to the dip-out chamber. For complete information write for Bulletin 593.

Each of these reverberatory furnaces melt and hold 35,000 lbs. of aluminum for direct-chill billet casting. One furnace brings melt up to temperature while other pours. Large doors permit easy bath access for charging, drossing, fluxing, alloying and furnace cleaning. Please write for Bulletin 591.



How the Foundry Industry Serves America . . . #8 of a Series



IRON CASTING EFFECTS 4-WAY SAVING OVER WELDMENT

Substitution of high strength gray iron in this compressor discharge casing resulted in an important 4-way saving: 38% saving in weight, 58% saving in material cost, 25% saving in manufacturing time, and 34% saving in machining cost, as well as a considerable saving in shipping costs.

Originally the casing was made as a cast-weldment. It was redesigned, however, to take advantage of the fluidity of molten cast iron and its low shrinkage during solidification. These characteristics permit successful gray iron castings to be designed in shapes which are impossible with other materials or processes.

Because the iron could be placed exactly where needed, it was not necessary to build up the weight of the part by the use of fastening devices, welding or multiple pieces. Neither did it require costly machining.

This is factual proof that modern iron castings can deliver outstanding performance and impressive economies when specified by industrial designers.

For the production of structurally sound and economical iron castings, Hanna Furnace provides foundries with all regular grades of pig iron . . . including foundry, Bessemer, intermediate and low phosphorous, as well as HANNATITE® and Hanna Silvery.

Facts from files of Gray Iron Founders' Society, Inc.



THE HANNA FURNACE CORPORATION

Buffalo • Detroit • New York • Philadelphia

Hanna Furnace is a division of **NATIONAL STEEL CORPORATION**

Circle No. 149, Page 151

In the interest of the American foundry industry, this ad (see opposite page) will also appear in

**STEEL
IRON AGE
FOUNDRY
AMERICAN METAL MARKET**



IRON CASTING EFFECTS 4-WAY SAVINGS OVER WELDMENT

Investigation of high strength gray iron in this new process design... (The text continues with technical details about the casting process and its advantages over welding.)

YOUR NAME HERE

FREE!

**REPRINTS OF THIS AD
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If you would like to have reprints of this ad to mail to your customers and prospects, let us know. Reprints will have no Hanna product message or signature, but will be imprinted with your firm name and address. Absolutely no obligation. To order your reprints, fill in and mail the coupon below.

**The Hanna Furnace Corporation
Detroit 29, Michigan**

Please send me _____ reprints of Ad No. _____
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Imprint as follows:

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I understand there is no charge for this service.

TRENDS IN EDUCATION

**TECHNICAL TRAINING—
AFS-T&RI STYLE**

by RALPH BETTERLY



Since Sputnik I, the words training, education, scientific manpower, research, engineering, and similar terms have taken on new importance. New training programs, courses, seminars, conferences, etc., have been developed for greater technological achievement.

But, to a greater degree, new programs offering intensive short courses have been developed for adult education. From this standpoint, industry has not been spared from the impact of the new importance of these educational responsibilities.

The metalcastings industry has not been excluded from the effect of these trends. Technological strides in recent years have made our industry ever more aware of the critical need for better trained personnel. Many years before the recent space age accomplishments, AFS had voiced the need for training programs specifically designed for operating supervisors.

This feeling became more acute in recent years when there became a growing tendency on the part of engineering education administrators to de-emphasize the so-called "hardware" or practical courses in engineering curricula. Many such programs have been reduced or eliminated.

Therefore, in 1956 the AFS Training and Research Institute program was approved. The first series of courses was presented in 1957 and since that date AFS-T&RI has served over fourteen hundred registrants from the industry. Practically all job titles have been represented in the program. However, according to original objectives, the greatest enrollment has been developed from key supervisory personnel. Students have attended from over 600 companies in 36 states, Canada, Mexico, and overseas countries.

For a closer look at this type of education, let's consider a typical AFS-T&RI class—"Production of Ductile Iron" held in Chicago, June 27-29. This class had about 50 per cent "repeater" students. Enrolled were:

8 Metallurgists, 6 Technical Salesmen, 5 Superintendents, 1 Foreman, 1 Plant Manager, 1 President, 1 Chemist, 1 Assistant Superintendent, 1 Quality Control Engineer, 1 Project Engineer, 1 Plant Engineer, 1 Cupola Operator, 1 Purchasing Agent, and 1 Works Manager.

Paralleling industry's support of these programs with registered students, competent specialists from foundries served as instructors. Most of these practical foundrymen are technical committee leaders in the AFS Ductile Iron Division. Students were encouraged to take notes and participate in discussion to receive maximum benefit from instruction.

Through this free interchange of ideas in the sessions and during "coffee breaks," participating foundrymen have excellent opportunities to discuss mutual problems. Registrants were advised to ask questions and concentrate on the salient points made by the instructors as many of these areas would be questioned in the objective test at the conclusion of the course.

In this class the know-how and know-why in ductile iron production was carried on enthusiastically for three days. This class was outstanding in individual participation. Lectures were supplemented with visual materials—including films and slides. Many students brought specific problems to the class and left feeling better-prepared to achieve solutions.

Group luncheons furthered the opportunity for friendly discussion of common problems. On the last day the test questions were written and answers discussed. Students then knew approximately how they did. Finally, group and informal pictures were taken and the first AFS-T&RI course on ductile iron came to a close.

After grade reports to students and management, and completion of evaluation questionnaires by the students, AFS-T&RI administrators then hope that "Knowledge Gained" will be "Knowledge Applied."

SAND HOT?

... National COOLEVAYOR's Here

The penalty of hot sand is *scrap*. But, all too often the cost of sand cooling equipment, for the small or medium size foundry, would appear to exceed whatever scrap savings may be effected.

The *National Coolevayor* was specifically designed to answer the foundryman's need for a highly efficient, yet low-cost separate cooling device which can be easily incorporated into most systems.

As you can see from the diagram, Coolevayor occupies little floor space. It's fast and flexible. It loads at the bottom and discharges at the

top so that you can elevate, as you aerate, as you *cool* the sand. The principle employed . . . that of pulling air through the sand to evaporate moisture . . . is simple, practical and foundry-proven. Relative cooling efficiencies have been documented and are indicated in the chart.

Why not *do something* about hot sand? Let a National engineer show you how Coolevayor can do double or triple duty in *your* shop . . . and pay its own way in reduced scrap, increased production and improved efficiency. Write for a Data Sheet on Coolevayor.

WRITE FOR COOLEVAYOR DATA SHEET



SIMPSON
MIX-MULLER®

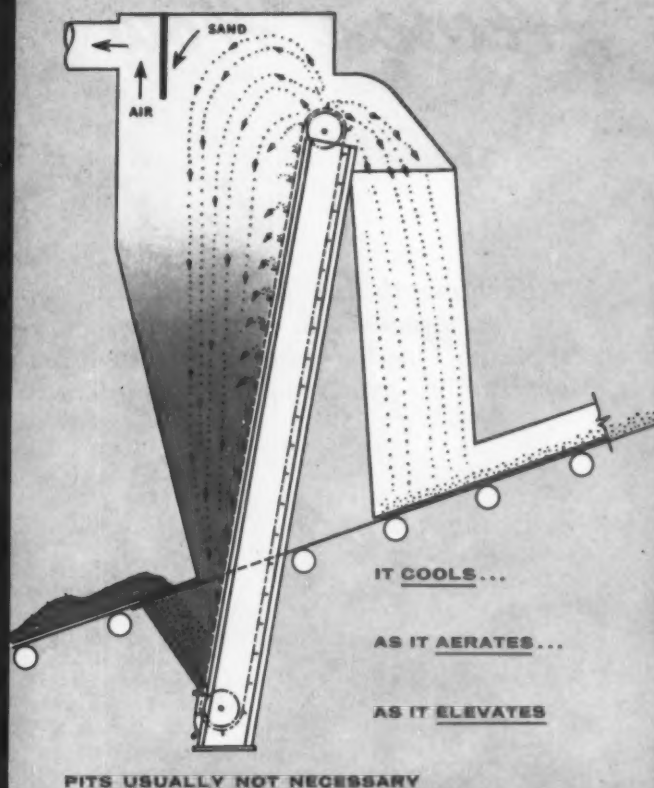
NATIONAL ENGINEERING COMPANY

630 Machinery Hall Bldg.

Chicago 6, Illinois

In Canada: 17 Queen St., East, Toronto 1, Ontario

MECHANI-MIZE
Foundry wise with
COOLEVAYOR



OPERATION

Within the large housing, a fast, flighted belt creates a virtual "sand storm"—while air is pulled through the sand to dissipate moisture and heat. Various degrees of cooling may be obtained by varying sand retention time and air volume exhausted. Floor space requirements are no more than 10 ft. by 4 ft. Unit may be charged by front and loader or shakeout belt.

CAPACITY

Cooleveyor is available in three models ranging in capacity of from 30 to over 60 TPH. Shown at right are a team of two Cooleveyors arranged to deliver tonnage in excess of 200 TPH. These units were displayed at the Foundry Show and are now operating at Albion Malleable Iron Company, Albion, Michigan.

NATIONAL COOLEVAYOR
RELATIVE COOLING EFFICIENCIES

Sand Temp. (°F) to Cooleveyor	*Average Sand Temp. (°F) after Cooleveyor	*Average Temp. (°F) Loss
200 to 215°	129.2°	77°
185 to 199°	120.4°	68°
170 to 184°	116.3°	60°
155 to 169°	112.8°	48°
140 to 154°	105.8°	44°

PERFORMANCE*

The above chart approximates the cooling efficiencies possible with Cooleveyor. Obviously, factors such as room temperature, humidity and sand make-up contribute to lesser or greater efficiency in a given time. For this reason, Cooleveyor, like many items of National equipment, is sold under a National Performance Guarantee, based upon your specific requirements.



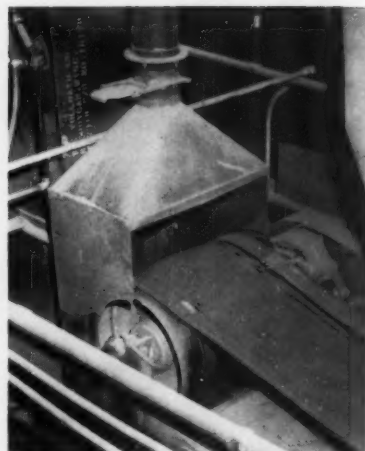
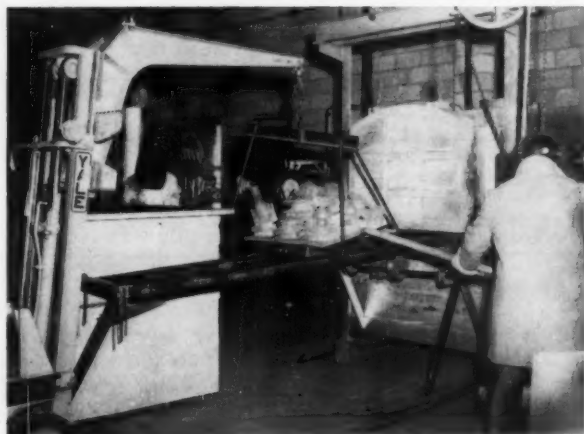
Here's How . . .

Each month this department brings you the newest developments in the foundry industry. These represent, in the opinion of the editors, ideas and applications which may help you do a better job.



. . . A new Navy casting alloy—60 per cent chromium, 40 per cent nickel—is forty-five times more resistant than 310 stainless steel to corrosion in oil-fired boilers. These bracelet hangars will be used in the superheater section of a steam-electric power plant. Service life of parts cast in the 60-40 alloy is estimated to be at least 17,000 hours. Foundrymen making furnace and boiler castings should take a close look at this new alloy and save your customers some grief.

. . . Alloy Steel Castings Co., Southampton, Pa., converted a fork-lift truck into a mobile crane. Shop-made boom slides up and down mast to manipulate this load of castings into and out of heat treating furnaces. There are many applications for this convenient crane runabout in other foundry departments—for instance, drawing patterns, unloading materials, moving castings.



. . . "We salvage 18 to 20 tons of back-up sand a day and drastically cut maintenance on our muller," according to James Behring, Vollrath Co., Sheboygan, Wis. Core wire, shot and tramp iron are removed from shakeout sand by screening it onto a conveyor belt which carries the material over a ceramic permanent magnet pulley manufactured by Stearns Magnetic Products Div., Indiana General Corp., Milwaukee. Pulley removes tramp metal and drops it into sump while clean sand falls into bucket conveyor which carries it to muller. Clean back-up sand insures against hand injuries and muller damage formerly attributable to metallic stowaways.



nothing tricky about it!

METAL BLAST simply has a new and much more economical process for making steel shot and grit! This is an entirely new and different manufacturing process and we have applied for a patent on it.

We *don't* use the conventional equipment and processes that others use. We *do* come up with a product meeting exacting laboratory tests and *guaranteed* to equal the performance of any steel abrasive on the market. Our savings in production costs are passed along to you and other potential users in the form of lower prices.

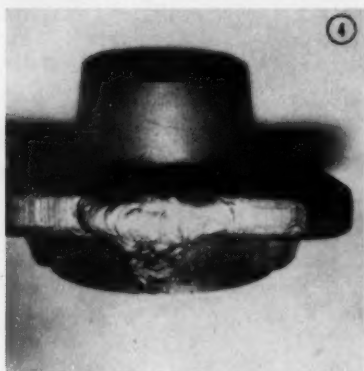
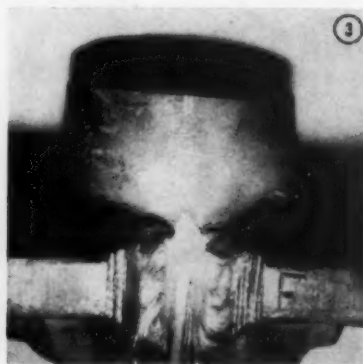
That's our story — and if \$165 per ton sounds good to you, why not at least investigate? A letter, wire or phone call (collect) puts you on the road to savings!

METAL BLAST, INC.

873 EAST 67th STREET • CLEVELAND 3, OHIO • Phone: EXpress 1-4274

ALSO IN: Chattanooga • Chicago • Cincinnati • Dayton • Detroit • Elberton, Ga. • Grand Rapids • Greensboro, N. C. • Houston • Los Angeles • Louisville • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh and St. Louis.

Circle No. 151, Page 151



... **new arc welding process** provides deposits that can be water quenched immediately without danger of cracking. Eutectic Alloys Corp. developed the technique which eliminates slow cooling between welding passes, preheating, and peening. Applications include: repair of cracked or broken castings; filling blowholes and machining errors; buildup of worn or broken gear teeth or other damaged surfaces; and joining cast iron to cast iron or to steel.

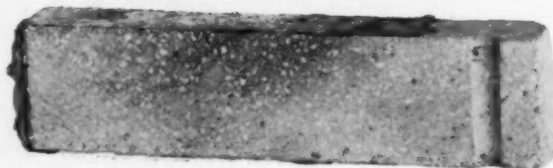
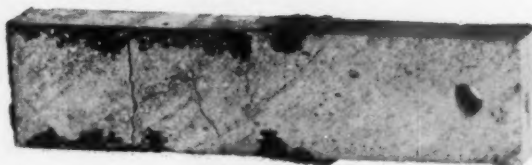
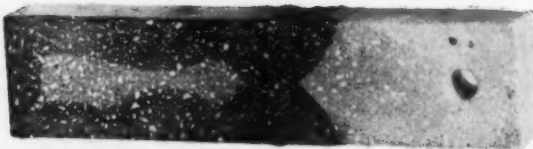
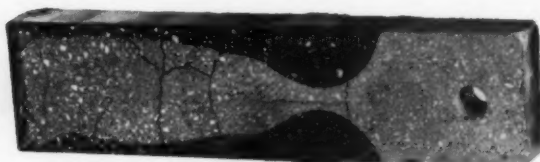
Pics show four-step sequence for repairing cracked belt bushing housing: 1) crack in flange veed out with chamfering electrode; 2) anti-stress grooves made on each side of vee; 3) grooves filled and vee thinly coated with sealing electrode; 4) vee filled with new low carbon, fine-grain electrode metal which can be water quenched and still remain machineable.

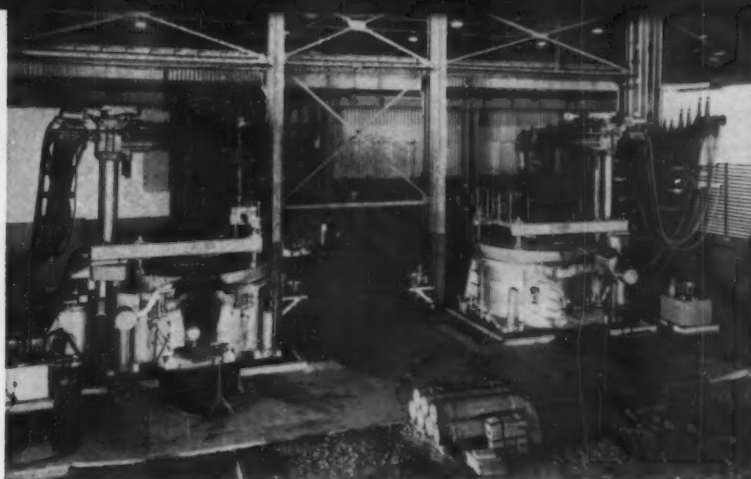
Here's How

Continued from page 24

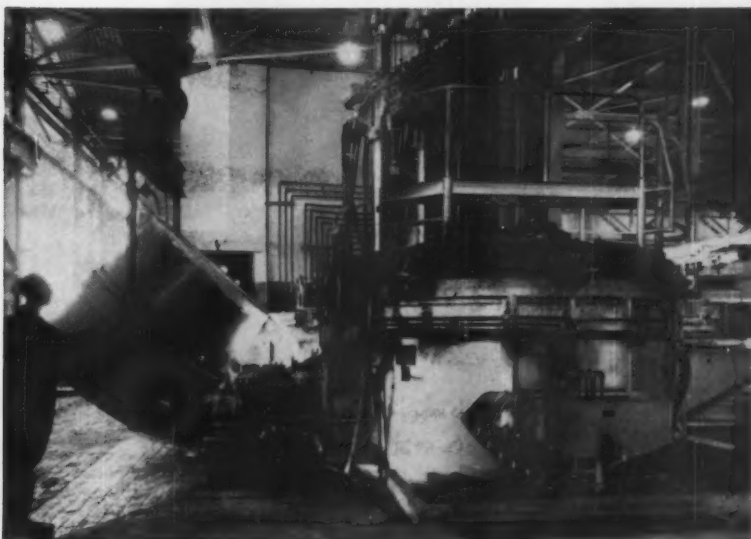
... **a new high alumina furnace brick** resists attack from molten aluminum. Picture shows effect of immersion in molten 7075 aluminum alloy for 30 days. Three conventional bricks on right show varying degrees of metal penetration. Brick on bottom was made of new refractory developed by Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp. High performance aluminum alloys are particularly prone to chemically attack the silica in reverberatory furnace linings.

This new brick and mortar formulation is low in silica so it is five times more resistant to attack by molten aluminum than previously available bricks. New refractory is also highly resistant to abrasion, impact, and thermal shock.





Two Lectromelt cold-melt batch furnaces melt gray iron.



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Circle No. 166, Page 151

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Circle No. 153, Page 151

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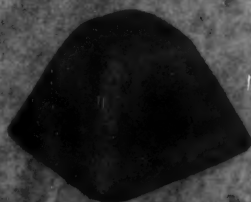
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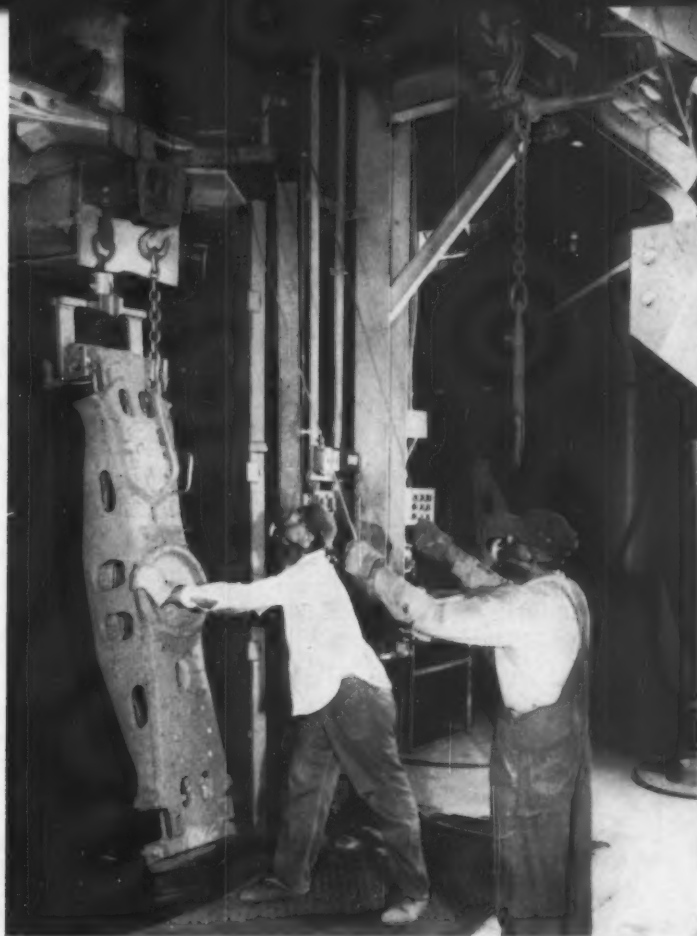


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Materials Handling Industry Needs Quality Castings . . . Can Use More

THERE ARE MANY BIG IF's blocking the way to greater casting sales in the huge materials handling industry. But the marketing opportunities are there! They exist in spite of the fact that this industry is already one of metalcasting's best customers.

How can these opportunities be discovered? It's simple! Ask! And this is just what MODERN CASTINGS has done. Presented here is the gist of a timely survey, barely completed at press time, which outlines in detail the answers of a selected group of top materials handling executives. All of these men are in companies making—in the aggregate—practically every mechanical handling device used in modern foundries today. Included are . . . monorails, hoists, fork-lift trucks, front-end loaders, overload cranes and chain, vibrating, oscillating, roller, belt, and pendulum conveyors.

Their companies are now using a variety of castings in their equipment. Listed here are some of the cast components reported in use on current models:

- axle mounting brackets
- bearing caps
- bearing housings
- bearing retainers
- brake drums

- brake and clutch pedals
- brake wheels
- bucket wings
- bushings
- carrier yokes

Continued on next page

More Castings

Will Be Bought IF . . .

1. Prices are competitive with stampings, forgings, weldings.
2. Better quality and reliability are achieved.
3. Foundries will help engineers design and redesign cast components.
4. Pattern costs are more reasonable.
5. Casting alloys have better weldability, strength, hardenability, machinability.
6. Machining is reduced to lower minimums by meeting closer as-cast tolerances.
7. Sales-mindedness is developed in foundry production supervisory personnel.
8. Castings are made lighter in weight.
9. Liaison between foundry and customer is improved.

Continued from page 31

chain attachments	grid bars
chain links	grippers
conveyor pans	hoist drums
conveyor posts	housings
counterweights	idler brackets
cowls	loadbars
cylinder caps	manifolds
deck supports	pillow blocks
drive axles	pulley hubs
drive, steer, and trail wheels	speed reducer housings
electrical brackets	sprockets
electrical contactor components	steer and drive axle housings
electrical enclosures	steering axles
elevator buckets	traction wheels
end stops	transmission cases
engine blocks and heads	trolley yokes
fenders	wear shoes
gear cases	wheels
gears	wire rope sheaves

Foundrymen have a big foot in the customer's door with these 50-plus different applications for castings.

Why Use Castings?

As might be expected, the important matter of cost is high on the list of reasons for buying castings—and also for *not* buying castings. One company feels that the casting process is the most economical for large repetitive type jobs. Another uses casting for short runs where they can't afford to tool up for a forging operation. In still other situations castings are cheaper than complex welded fabrications—unless only several pieces are needed.

Casting is regarded as an ideal fabricating technique for highly complex shapes. No other process has the versatility of metalcasting when it comes to intricate configurations with internal cavities shaped by cores.

Casting also is most flexible in the broad spectrum of alloys available and the size parameters which are practically limitless. Engineers like the design freedom possible when working with metalcastings. Stresses can be effectively distributed throughout a variety of section sizes without dangerous stress concentrations.

Makers of handling equipment like the as-cast finish on surfaces that don't have to be machined. The excellent machinability of cast metals—especially gray iron—contribute an appreciable net savings in finished part costs.

Improvements Needed

Great market opportunities in materials handling equipment are waiting for foundrymen, say material handling executives. Every one of these manufacturers would buy more castings IF:

- 1) Castings were cleaner—free from excess sand, surface porosity, and other defects affecting welding, strength, and appearance.
- 2) Castings had consistent quality—chemically, metallurgically, and physically.
- 3) Castings were cast to closer tolerances to minimize machining.
- 4) Castings were not warped.
- 5) Castings had better appearance.
- 6) Castings were not shipped with defects.
- 7) Castings were made of heat treatable alloys that could be welded with simple preheat and post-heat methods.
- 8) Castings were less expensive—especially relative to weldments.
- 9) Castings had higher strengths, improved machinability, and better hardenability.
- 10) Castings could be made in sand comparable to die castings and precision investment castings.
- 11) Castings could be redesigned stronger and lighter.

One manufacturer says he would use more castings if pattern costs were more reasonable. Several

voice a need for better liaison between foundries and their customers. This can start with casting sales engineers helping with the design or redesign of parts, selection of alloys, and use of proper casting processes. Sales-mindedness can carry down through the various foundry departments—especially on the part of production supervisory personnel. Customers can be kept alerted to production problems which may affect delivery dates. "Don't wait until the day the castings are to be delivered and then tell your customer delivery will be two weeks late," advises one top executive. "Keep us posted in advance so we can adjust our production schedules to meet such emergencies."

One purchasing agent complains that foundries will not absorb charges accruing from machine time expended by customers on castings rejected when internal defects are revealed. Some mutually equitable arrangement needs to be worked out.

Several emphasize the need for cooperative programs between the casting and welding "fraternities." Traditionally competitive, they have been united in "shotgun weddings" to form cast-weld structures. Components are first divided into segments optimum for casting. Then the individual cast parts are welded together to form the final composite fabrication. Wrought and forged shapes may also enter into the welded combinations. One particular manufacturer combines 14 individual castings and 28 steel plates into a one-piece welded structure.

"If foundrymen are to compete with other processes and materials they must learn something about forging, stamping, welding, plastics, powder metals," says another executive.

"Know the strengths and weaknesses of those processes and materials if you expect to expand your markets."

The Long-range Picture.

The president of one company suggests that *the metalcastings industry could serve their customers better by establishing a central agency for analyzing casting requirements based on need . . . rather than on promotion of specific metals or metal combinations.* "A division of this effort is costly, time-consuming and ineffectual if it is not geared to common and well-defined industry objectives," he declares.

Such an ambitious program requires unprecedented cooperation between some 20-odd metalcasting industry societies, associations, and institutes now operating independently with relatively narrow goals keyed to short-range, specific needs of their constituents. This action may come about only by realizing that the survival and growth of the metalcasting industry depends on long-range, united effort. Foundries are traditionally small—far too small to carry on the expensive fundamental research that is needed to stay constantly competitive. It has been suggested that a united effort, subsidized by every foundry, in direct proportion to the gross value of castings shipped, is one answer to guaranteeing our future.

A Special Report

by JACK H. SCHAUM, Editor

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Compression Casting

Now you can cast the impossible!

This novel technique makes it possible to cast large thin-walled ribbed parts. Applications include ailerons, wing surfaces, fuselage sections, automobile hoods, railway car side and bottom panels, motor and river boat hulls, and wall facings for buildings. It lends itself to casting zinc, magnesium, copper, and even steel!

A. J. STEIGER

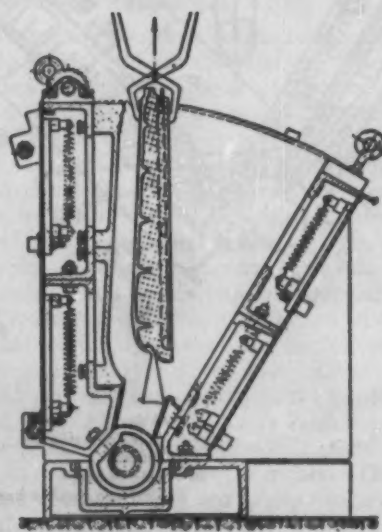
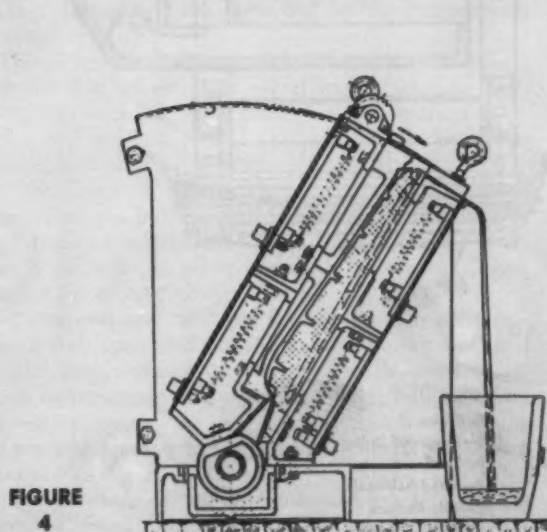
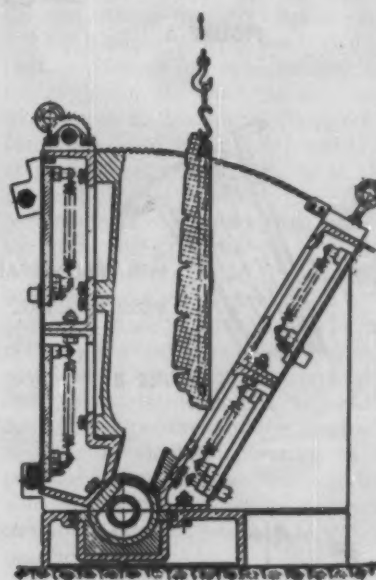
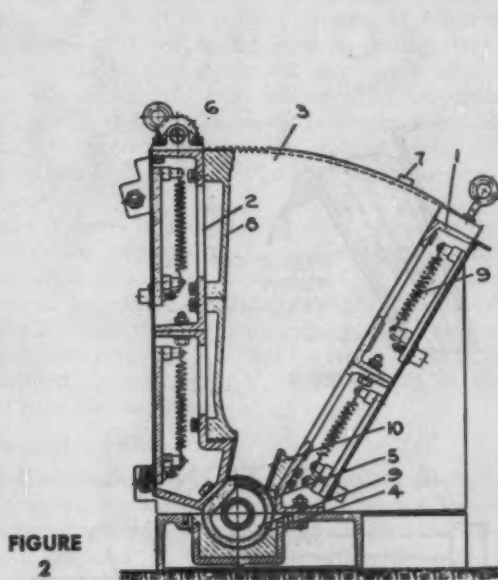
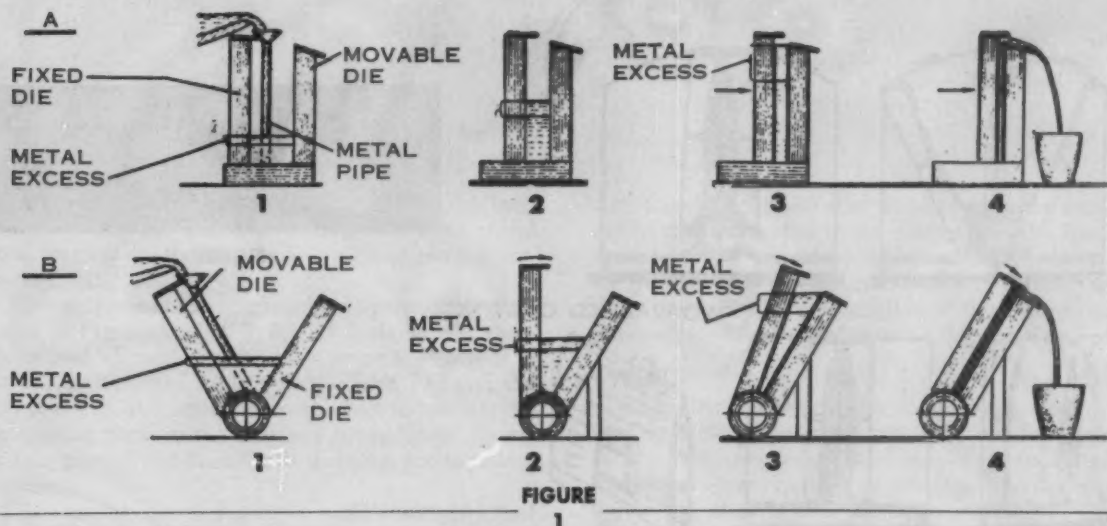
COMPRESSION CASTING is done by machines that operate on what might be termed the "waffle-iron" principle. Molten metal is compressed between mold halves made either of metal or fitted with sand inserts shaped to the casting's required surface.

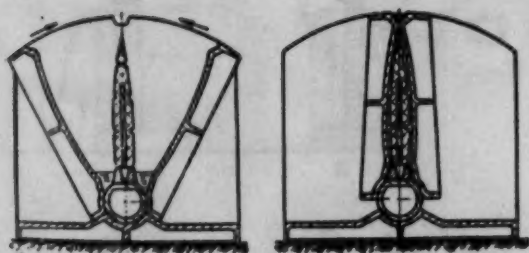
Compression casting was first introduced in USSR as a labor and power saving method in aircraft and automobile manufacture. The Moscow journal *Liteinoye Proizvodstvo* (Casting Production) gave the following description of the process, termed cheaper and simpler than "drawing, bending, or riveting which

require the use of huge and very powerful presses."

The essence of the new method, illustrated in Fig. 1, is that thin-walled parts are machine-cast with two convergent dies. One may be fixed and the other movable toward it either by parallel sliding (A) or rotation around an axis (tubing) (B). One or both dies can be lined with wash or sand.

Casting formation is a 4-stage process: (1) pouring the metal slightly in excess of the part in weight; (2) bringing the die walls together and gradually filling the mold with molten metal; (3) metal crystal-





TWO-WALLED CASTING

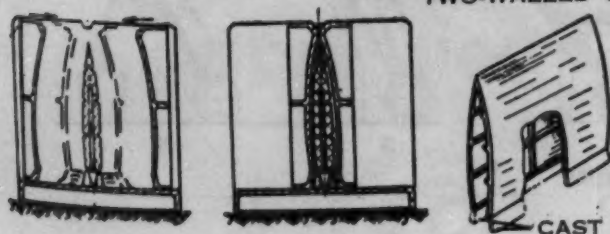


FIGURE 6



FIGURE 7



FIGURE 8



FIGURE 9

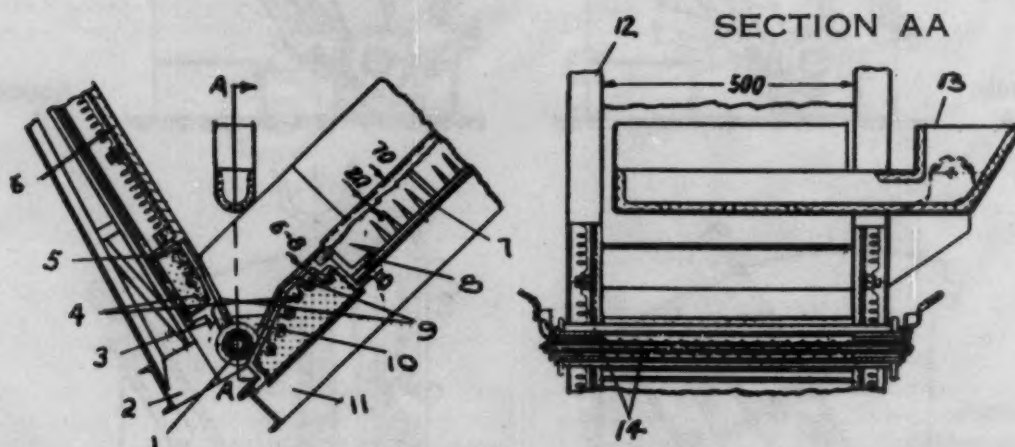


FIGURE 10

- 1—Axis
- 2—Movable half-mold
- 3—Knife
- 4—Electric heater
- 5—Cast-iron crucible box
- 6—Metal die
- 7—Core

- 8—Frame
- 9—Fireproof lining
- 10—Sand
- 11—Fixed half-mold
- 12—Side flanges
- 13—Pouring device

lization on die walls and compression of surplus metal from the mold and (4) joining the solid metal skins formed on the die walls and final casting formation.

The compression casting machine operation is illustrated in Figures 2, 3, 4, 5, 6, and 7, showing various stages and elements in the new process. Figure 2 is the casting machine itself with the fixed (1) and the movable (2) dies equipped with electric heaters (9) for heating them to the required temperature. In the bottom part of the fixed die is a device for installing the core.

The movable die is bolted to mold insert (8) that forms the casting's outer wall. It also has electric heaters. This die is fixed to hollow tubing (4) rotation of which swings it over to the required casting thickness. Between the dies in the initial position, at the bottom, is crucible (10) with sealing (5). More than enough metal to fill mold cavity is poured into the crucible. Turning mechanism (6) with stopping device (7) brings the walls of the dies together, properly spaced.

Figure 3 shows how the sand core is placed in the die. Following insertion of the core, the special crucible mold is filled with metal. Then the die walls are moved toward each other forcing metal out of the crucible, up through mold cavity, and surplus overflows into crucible (Fig. 4). Figure 5 shows how the finished casting, together with the core, is removed from the machine.

Effects of Metal Flow

The compression system is described as easily adaptable to varied casting configurations. Figure 6 shows both angular and parallel convergence of dies in compression machines designed to produce two-walled castings. Shown in Fig. 7 is a ribbed panel with walls 1/10-inches thick produced by the compression process.

The diagrams in Fig. 8 and 9 illustrate the effects that the flow of extruded metal has on casting crystallization on mold walls, through a temperature drop. The metal outflow is said to make the process continuous and produce a "microgranular structure without any kind of defects in the form of shrinkage porosity or gas bubbles." The swift metal flow reaches 5 feet per second and up, illustrated in Fig. 9. This contributes to what is called "automatic degassing" of the casting.

"The speed and mode of flow of the extruded surplus metal—governed by the rate of movement and angular displacement of the mold walls—exert a decisive influence upon the process of crystallization in the metal layers," writes *The Technical Digest*, a Prague engineering news journal, analyzing the new process.

"By variations in the kinematics of machine operation, the conditions of crystallization of the metal

can, therefore, be adjusted so as to give the required mechanical properties to the casting and the specified smoothness to its surface. In other words, this method permits the crystallization of the cooling metal to be controlled by the variation of the hydrodynamic parameters of the flow of metal in the mold."

Casting Steel

When first developed, the compression system was used in casting aluminum and other non-ferrous metals like zinc, magnesium, and copper alloys. Recently, the system was applied in an experimental project to casting steel panels of large dimension with a thickness of 0.16 to 0.20 inches, according to the Russian casting industry's trade journal.

The Russian journal said that the experimental unit developed for steel casting had an adjustable tilt angle for the movable die, ranging from 30 to 65 degrees to horizontal. Without complicating the machine's drive, this made possible the staged control of molten metal flow velocity in the range between 1.6 and 6.5 feet per second. These hydrodynamic parameters were found most efficient in regulating the steel casting process.

Shown in Fig. 10 are the essential elements of the compression machine developed for casting steel. The optimum conditions for casting large thin-walled steel plate by the compression casting machine were given as follows: 392 to 482 F. temperature of the special mold, movable metal dies, and side flanges; 3056 to 3092 F. temperature of the steel when poured; 2912 to 2948 F. steel temperature in the special mold crucible before compression; and 6.6 feet per second velocity of metal flow during compression. Under these conditions steel panels 0.16 to 0.20 inches thick were produced.

Operational Advantages

Compression casting has numerous advantages over pressing for the production of thin-walled ribbed plates. The dimensions of cast plates can be larger than those made by pressing under present technology. While the production of ribbed plates 218 to 272 square feet in area and 0.08 to 0.12 inches in thickness is not yet feasible by pressing, such large parts can be made without difficulty by the new casting machines. These machines are, in turn, comparatively simple in design, inexpensive to manufacture, safe to operate and do not require great skill of operators.

Pressure comparable to that used in metal pressing is not required by the compression casting system. The pressure exerted by the molten metal on the mold does not exceed 0.08 to 0.1 pounds per square foot. Owing to the machine's large capacity and the low price of materials, the cast parts can be made at a low net cost of production. The equipment, being compact, does not occupy a large floor space in the shop.

by IRVING ELBAUM

Are You Murdering Your Business?

You can! Check these factors and see whether your business is in danger:

- . . . Lack of competent people
- . . . Lack of people with business experience
- . . . Lack of people with well-rounded experience

Here's an 11-point guide to keep your business alive and healthy.

MOST BUSINESSES do not die natural deaths. Their managements kill them! Whether the foundry business firm is a sole proprietorship, a partnership, or a corporation doesn't seem to matter. Homicide, accidental or otherwise, is committed. And the murder techniques are indeed varied. Most popular weapons are: Incompetence . . . Lack of Business Experience . . . Neglect . . . Fraud by the Owner . . . and Lack of Rounded Experience.

There seems to be a popular misconception regarding the ease with which the life of a foundry can be sustained. It's a tough job.

Superimposed on this general business difficulty is the hardship faced by the small operator. His business is usually not too well capitalized, is not as well controlled as a larger operation, generally faces shortages of working capital constantly, and receives a tighter credit line than offered larger competitors. The advantage of having everything under the owner's thumb is more than offset by the disadvantages concomitant with smallness—inadequate financial reserves and difficulty in decentralizing responsibilities.

A survey made by Dun & Bradstreet indicated that over a 50 year period only 78 out of every 10,000 businesses fail. This is truly amazing since many new businessmen have had little or no prior experience.

Another Dun & Bradstreet survey showed that two out of every three concerns that failed had been in business for five years or less. This fact isn't surprising. Yet it should encourage those among you who are over the five-year hump. No guarantee, of course, that it couldn't happen to you.

Just what are the basic, the broad reasons for business mortality? In order of importance, here are the reasons for 9162 failures studied:

Incompetence	42%
Lack of business experience	31%
Lack of rounded experience	14%
Neglect	6%
Fraud by the owners	4%
Miscellaneous	3%
	<hr/> 100% <hr/>

Let's examine each group to learn what can be done to control some of the controllable factors.

Incompetence: Generally speaking, incompetence can be broken down into three categories: physical, emotional, and economic. Overlaps and vicious cycles exist among these groups.

Physical incompetence is represented by an individual who cannot take the long hours or the heavy work so necessary for the successful operation of a foundry or pattern shop. The antidotes would seem to be: 1) selling the business before it dies on you; 2) transferring the heavy duties to an employee (if possible); 3) renting or buying labor-saving devices; or 4) having a close relative help you with some of the details.

Emotional incompetence is a common reason for the failure of many businesses. Before anyone goes into business he should ask and answer the following questions with all the sincerity he can:

Do I realize that I may lose money and be in a rough spot fairly often?

Can I take the responsibility of paying my creditors and my workers on time?

Will I mind working long hours?

Do I care for this type of business?

Inadequate initial capital is the largest factor of economic incompetence. The wise man who is thinking of going into a small operation should take time out to make a reasonably accurate calculation as to his financial needs to keep the business going for at least a year. Unfortunately, far too many people start on the proverbial shoestring. They feel that everything will take care of itself once the initial outlay for machinery, equipment, supplies, furniture, fixtures, deposits, licenses, etc., is made.

It is most vital to prepare a simple, yet accurate, budget before the metalcasting business is begun. Show the estimated amount of cash needed not only to acquire the items mentioned above, but also to meet payrolls, overhead and to carry those customers who are not on a cash basis. At least half of all businesses are begun without making this type of calculation.

Lack of business experience: This covers lack of experience in busi-

ness in general as well as in the particular line. The remedies will be suggested in many cases by reviewing the following list of typical symptoms of this illness: (1) inadequate or no records; (2) overextension of credit; (3) poor receivable collections; (4) taking on too large a fixed overhead; (5) not reducing the variable overhead when the going gets rough; (6) overbuying or underbuying; (7) poor location; (8) not knowing how to combat competition; and (9) not knowing the business.

Lack of rounded experience: This ailment reflects itself in the technique of favoring one department of the company to almost a complete exclusion of the others. Former salesmen generally are the greatest violators. They have become so accustomed to seeing business through sales lenses that they find it hard to place purchasing, credits, collections, etc., in their proper positions on the business scale.

Unbalance can often be equalized by using an accountant. His financial statements can prove most significant in highlighting distortions that are occurring due to misplaced emphasis on any departments in the foundry.

Neglect: This is generally due to: (1) poor personal habits; (2) poor health; (3) domestic difficulties. Some of these foibles are difficult, others impossible, to eradicate.

In the case of a temporary health deficiency, it may be advisable to turn over the foundry operation to a trusted employee, a close relative or both for a short while.

Fraud of the owners: This is symptomized by false financial statements, illegal disposition of assets, deliberate overbuying. Luckily for the business community this group represents only a small percentage of the total failures.

Miscellaneous: This covers such items as employee frauds, disasters, and unknown reasons for failure. Employee frauds and such disasters as fire, burglary, boiler explosion, etc., can be protected against at reasonable cost. The advice of an insurance broker should be sought not only at the inception of a business but on a continuing basis. All too often a business is adequately covered for various types

of risks when it begins. But then with maturity sometimes comes a tendency to let the insurance program remain static. Business is dynamic. Therefore an insurance program covering its risks should change from time to time.

Conclusion

An acute awareness of the causes of failure can go a long way toward preventing failure. Action can go a longer way. The following list, by no means exhaustive, should give you action ideas sufficient to prevent you from killing the source of your food, clothing and shelter.

- (1) Join a trade association.
- (2) Read as many trade journals as you can.
- (3) Question suppliers and their salesmen about new developments.
- (4) Talk to your attorney, accountant, banker, and insurance man about those phases of your business which come within their jurisdiction.
- (5) If you have a partner, discuss all phases of the business with him regularly. Remember, you're married to him commercially.
- (6) See your doctor if you're chronically tired. If you're not, have an annual checkup.
- (7) Keep accurate, up-to-the-minute records.
- (8) Review your list of receivables regularly and often. Keep after the slow ones.
- (9) Digest your financial statements. Remember, they are not novels to be skimmed through. One item that your hurried eye misses may well mean the difference between success and failure over the long pull.
- (10) If, as, and when things look hopeless don't commit any fraudulent act. You may regret it the rest of your life. Discuss your apparently insoluble problem with the proper professional man.
- (11) Don't listen to the army of armchair generals. Many people delight in giving business advice, unasked for though it may be.

Irving Elbaum is a certified public accountant serving foundries in the Los Angeles area.

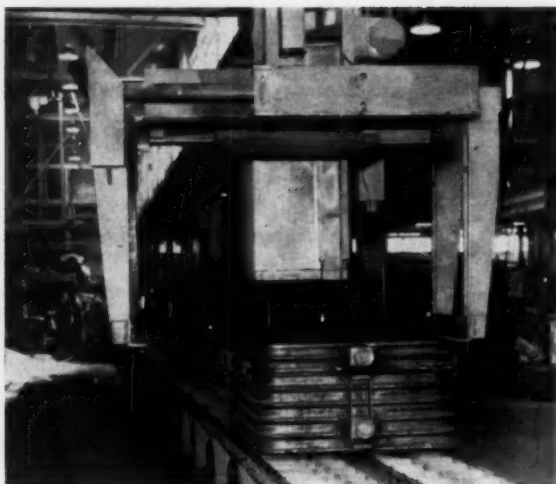


Figure 1

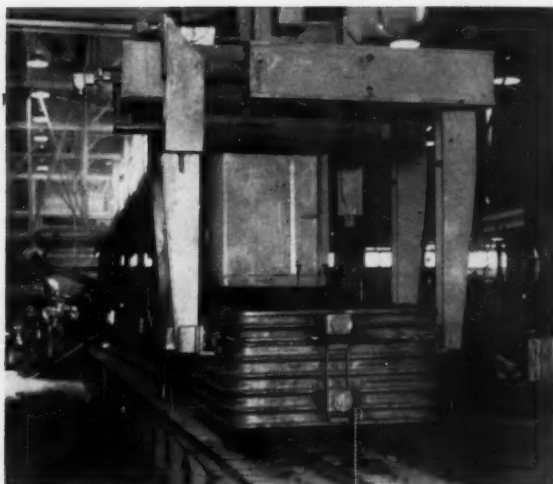


Figure 2

Stacker Cranes Link Molding, Pouring, Shakeout

Here's a new concept of materials handling. This equipment is used for:

- Storing molds, patterns, castings, and supplies.
- Handling hot metal.
- Moving flasks, bin boxes, and pallets.
- Loading furnaces and ovens.
- Dumping and charging operations.

Eliminated are crane cable failures, overhead trucks, and bumpy floor problems. It's built-in safety!

WHAT'S A STACKER crane? Take the wheels off a fork-lift truck. Attach it to a telescoping-rotating mast. Then hang this assembly from a bridge crane. And you have it!

A stacker crane is the latest material handling device linking the molding, melting, and casting processes. These cranes have all three dimensions of movement, plus a fourth dimension—rugged versatility. Here's a foundry robot that takes the crane operator out of the rafters and puts him right down at the point of contact with the material he is handling. This proximity gives the operator that last inch of dimensional accuracy so often lacking when molds are moved or metal is poured.

Two of these cranes are busily gliding up and down the main bay in the new foundry of Neenah Foundry

Co., Neenah, Wis. Intent on de-bugging the problems inherent to getting a new foundry "on stream," Foundry Superintendent Henry Van Handel stopped long enough to comment, "These two stacker cranes are sure doing a bang-up job of linking our molding, pouring, and shakeout into a smooth operation."

In Fig. 6 you can observe the rugged construction of the telescoping mast suspended from the bridge crane. The mast can raise a four-ton load 6 feet 4 inches above the floor. The mounting on bridge crane trolley permits 360-degree rotation of the mast, trolley movement back and forth across the bay, and bridge travel up and down the length of the shop. Electric motors drive all these directions of travel.

The open cab in which the operator stands can move up four feet on its own vertical guide posts

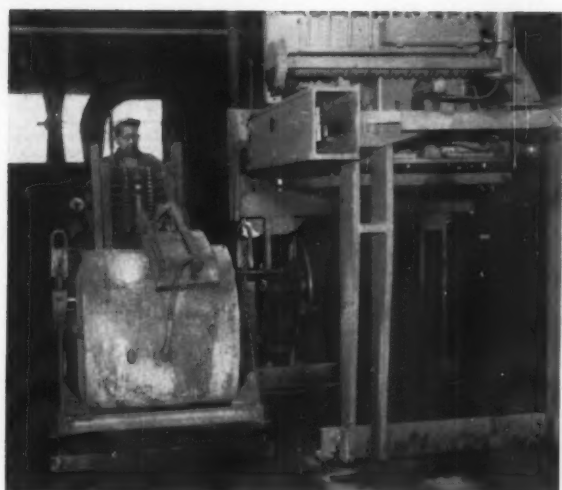


Figure 3



Figure 4

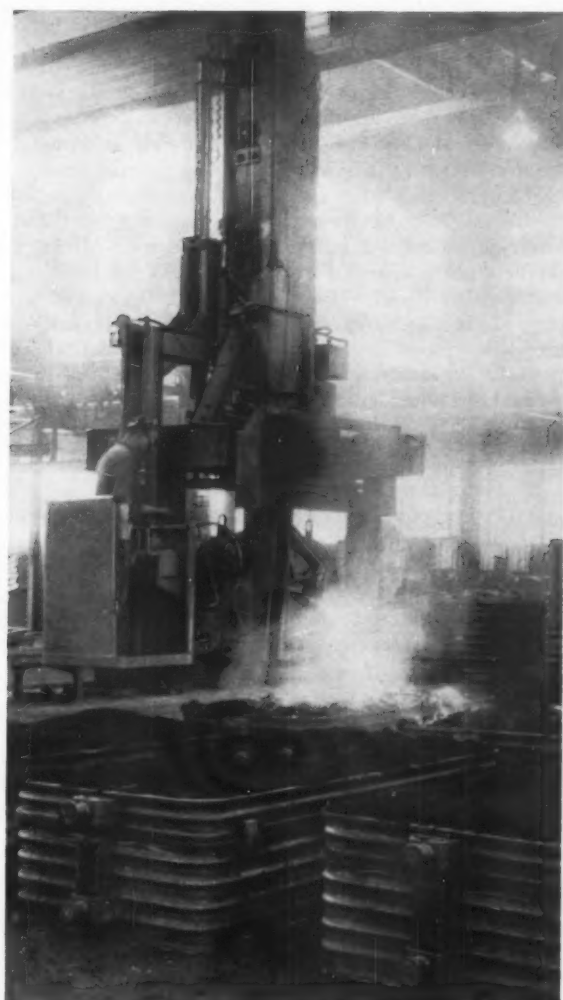


Figure 5

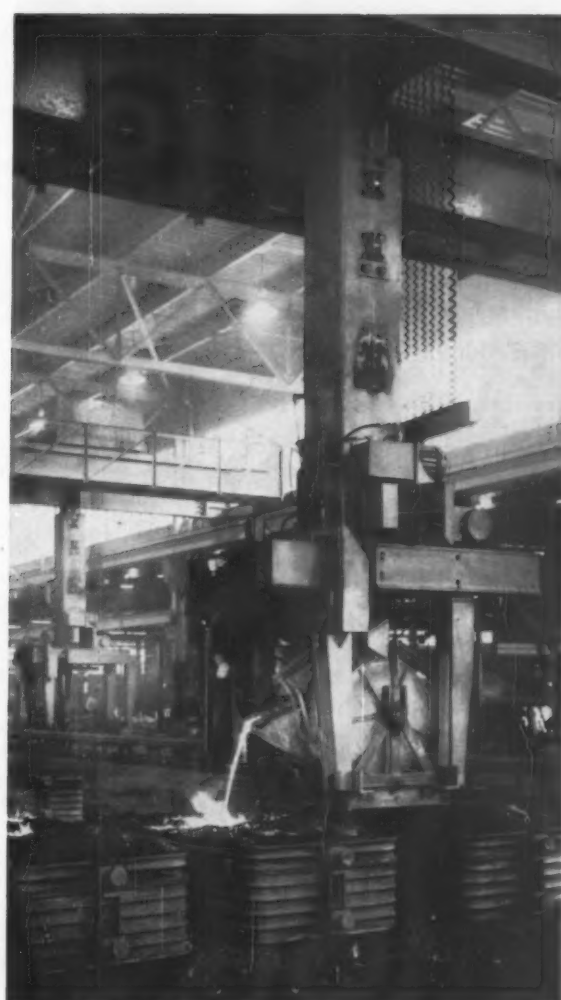


Figure 6

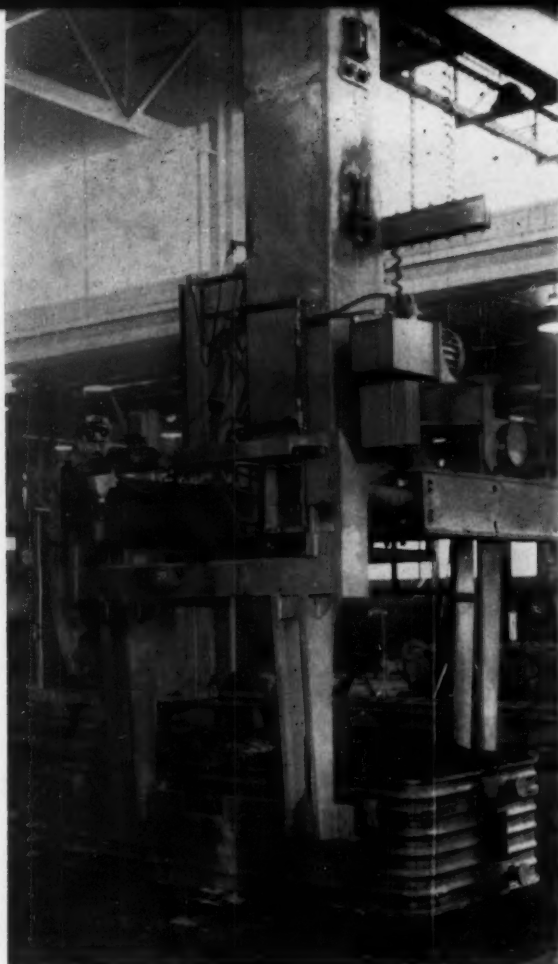


Figure 7

attached to the mast. The operator has the advantage of being in close proximity to the work his crane is performing. He needs no helper on the floor to act as a remote guide for the crane movements. Since the cab is easily lowered to floor level the operator can conveniently get in and out to perform other duties.

Hydraulic controlled "grabs" on the bottom of the mast can be opened as wide as 86 inches and brought together as close as 27 inches. These two vise-grip grabs are used at Neenah to pick up flasks, molds, and ladles of iron.

Doing the Chores

Now let's watch a stacker crane perform its chores in the Neenah foundry. Molds are made by sand slinger at one end of the foundry. Each mold contains two cavities for gray iron manholes. Completed molds are set on a roller conveyor equipped with a drag link chain which pushes molds to pouring area. When mold reaches destination, stacker crane moves over and straddles the mold (Fig. 1).

Grabs are hydraulically closed until they grip opposite sides of drag flask. Then mold is lifted off conveyor (Fig. 2) and carried over to pouring area where it is set on the floor. To control the flow rate of molds from the molding area, stacker crane operator has a radio-control device with which he can stop

and start the drag link chain on mold conveyor.

While one crane is delivering molds to pouring area a second stacker crane is filling them with molten iron. Hot metal is delivered from cupola in a ladle supported on a special steel pallet easily handled by fork-lift truck (Fig. 3). Stacker crane straddles the pallet and grabs move in to clamp onto it. Operator lifts the 2500-pound ladle of iron (Fig. 4) and travels over the line of molds waiting to be poured. A spotlight on crane is positioned so when it is shining directly into pouring sprue the operator knows he is properly located for pouring (Fig. 5).

Wheel for tipping ladle is conveniently located in front of him. Pouring is effected with speed and a minimum of spillage (Fig. 6).

Mold Maneuvering

Shortly after pouring, the mold transfer stacker crane picks up the poured mold (Fig. 7) and carries it to conveyor leading to shakeout station. If longer cooling time is needed the molds are stacked 3-high for the desired interval. This maneuver frees valuable floor space for more molds flowing out of the molding area.

As soon as an area is cleared of poured molds the sand floor is raked smooth. To do this, grabs are lowered to floor level and the stacker crane runs back and forth across the pouring bay leveling off the sand.

Now you can appreciate how Neenah relies on these two stacker cranes to keep molds and metal smoothly flowing into and out of the pouring area.

Stacker cranes have other uses than those demonstrated at Neenah Foundry. For instance, at West Michigan Steel Foundry Co., Muskegon, Mich., a smaller unit is equipped with two forks for handling materials on pallets. Boxes of castings are racked up in their storage area. Installations of this type are ideally suited to servicing pattern storage areas where patterns are traditionally stacked from floor to ceiling.

Stacker cranes have successfully handled:

- 1) Storage of molds, patterns, castings, and supplies.
- 2) Hot metal handling.
- 3) Production handling of flasks, bin boxes, and pallets.
- 4) Furnace and oven loading and unloading (i.e. heat treating, coremaking, etc.).
- 5) Dumping and charging operations (i.e. blast loading, casting sorting, and inspection operations).

Stacker cranes can be furnished with many devices including roll-over attachments, magnets, joy stick multiple motion controls, automation, broken cable elevator safety devices, and most any device to do a handling job in a crane bay.

Cranes can be built to handle maximum loads of only 250 pounds or as large as 15 tons. Vertical lifts can be as high as 50 feet. In most instances the stacker crane can be added to a bridge crane.

And stacker cranes possess a number of safety features which eliminate such worries as crane cable failures, rough floors, upsetting of trucks caused by overloading or too high a lift, and poor communication between crane operator and fellow workers.

Are Low Phosphorus and Sulphur Steels Practical Today?

by DON ROSENBLATT
American Foundry & Machine Co.
Salt Lake City, Utah

JOHN ZOTOS is to be congratulated for the excellent article on "Low Phosphorous and Sulphur for High Ductility and Toughness in Steel Castings" which appeared in the March issue of MODERN CASTINGS. The fine work done at Rodman Laboratories on producing higher ductility cast steels by using vacuum and atmosphere melting to achieve extremely low phosphorus and sulphur contents should be of more than academic interest to commercial steel foundries. However, there remains serious doubts as to the immediate practical value of the methods recommended by the author for improvement in steel castings.

Those of us primarily concerned with producing steel castings to perform a given function can scarcely be so presumptuous as to represent casting quality in terms equated only to classical tensile properties of the steel itself. Neither the chest measurements nor the chemical composition of an athlete will enable the coach to predict his performance. The whole spectrum of specifications for steel castings and the metal from which they are poured is at issue if such philosophy is extensively pursued.

Even though a test bar (for tensile or impact testing) is of the same metal composition as the casting it purports to represent, it can not accurately predict castings' properties. Residual stress, a shape sensitive quality, has marked influence.

Boegehold demonstrated how dangerously misleading test bar data can be in his comprehensive study of a decade ago. In this he carefully compared test bar results to actual parts service performance.

Low metalloid content is most certainly effective to some degree in improving test

bar properties (as Zotos has shown). But it is not directly influential in residual stress distribution. The origin and distribution of residual stress are closely related to heat treating practices, lower carbon, and better balanced alloy compositions. Therefore, these characteristics produce a more realistic correlation between improvements in test bars and improvements in castings than low metalloid content.

The Ordnance requirement for 132,000 pounds per square inch tensile with 25 foot pounds at minus 20 F. is readily obtained in many higher phosphorus and sulphur alloy compositions by proper selection of either carbon content or tempering temperature. The 157,000 pound per square inch tensile strength with 15 foot pounds at minus 20 F. ordnance requirement is also attainable in higher phosphorus and sulphur steels by using a 1200 F. tempering treatment on an appropriate alloy composition with about 0.20 per cent carbon.

The Bochumer-Verein process in Germany is producing vacuum melted steel in commercial quantity. Higher reduction of area and elongation values in forgings made from vacuum cast ingots are reported, although increased notch-bar impact values were not obtained.

Eventually the low phosphorous and sulphur, vacuum melted, cast steels will find a place in commercial foundries. However, until the designers of steel castings have a more sophisticated grasp of casting metallurgy, and until specification writers expand the scope of the present type of steel castings specifications, this work rightly belongs within the confines of the subsidized research organizations where it now resides.

Good Castings, Patterns Start with Ideas

Ground rules and training may be the same, but it's the creative adaptation that counts.

EVERY YEAR when the winning entries of the AFS Kennedy Memorial Apprentice Contest are displayed at the Castings Congress, foundrymen and patternmakers gather round and argue the merits of the patterns and castings. More than often the "old pro's" show a preference for an "also ran" entry and wonder why it wasn't included as one of the five first-place winners.

MODERN CASTINGS thought you would be interested in learning how and why the five winners pictured on the right were selected. Altogether some 461 patterns and castings were entered in this year's contest. Local contests whittled this group down to 109 finalists. These entries were shipped to University of Illinois, Navy Pier Branch, Chicago, where twenty well-qualified foundrymen and patternmakers served as judges.

An entire day was spent on judging. Judges scored each entry in their division and the winners were placed in order of total points awarded. Here are the bases for maximum point allocations. (Points shown are the maximum allowable.)

Wood patternmaking: 1) accuracy according to drawing—35 points; 2) moldability—35; 3) workmanship—20; and 4) time—10.

Metal patternmaking: 1) accuracy according to drawing—50; 2) workmanship—30; and 3) time—20.

Iron, steel and non-ferrous molding: 1) gates and risers—20; 2) yield—10; 3) cleanability—10; 4) general appearance—20; 5) soundness—25; and 6) time—15.

Wood Pattern—Each contestant worked from identical blueprints of a gray iron bracket. According to the judges the winner was Adam Kravetz, Progress Pattern Co., Detroit. His mahogany pattern, shown on opposite page, displayed substantial workmanship. Sturdy construction was adequate for the 25 mold requirement placed on the pattern. It was designed

so no loose pieces were needed. Pattern is split with core on drag half. Top half of pattern is set on bottom half when making the cope after drag ram-up. Pattern had high moldability with no bad pockets.

Metal Pattern—Judging in this category is extremely close. The difference between the first and second place winner was based on only a few thousandths of an inch in dimensional accuracy. Winner, Charles D. Lee, Caterpillar Tractor Co., Peoria, Ill., also avoided a high polish on his pattern. High polish tends to encourage undesirable ram-off.

Iron Molding—Winner Arvo Tynilainen, John T. Hepburn Co., Ltd., Toronto, Ont., entered a well-planned, skillfully made casting. Production time was unusually fast. Risers were placed to provide feed metal at heavy sections with lap connections (kiss-gates) aiding easy removal and finish grinding. Gating system choked well keeping out all slag and dirt inclusions. Parting showed no flaws, swells were absent. Finish was unusually smooth and free of penetration.

Steel Molding—This winning casting was made by James C. Leinss, Maynard Electric Steel Casting Co., Milwaukee. Note that gating is through two blind risers which used Williams cores to achieve atmospheric pressure feeding. Chills were used to achieve directional solidification. Absence of scabs and veins indicates good sand peel and maximum cleanability.

Non-Ferrous Molding—A good salable aluminum casting won this contest. Made by Peter E. Durben, Eck Foundries, Inc., Manitowoc, Wis., the casting was made with economical use of time, gates and risers. It contained no apparent shrinkage and was free from sand holes, inclusions, crushes, etc. The casting had high yield and good cleanability.

Judging from the quality work produced by these and many other apprentices, the next generation of foundrymen is entering our industry well versed in metalcasting fundamentals.



Steel Molding



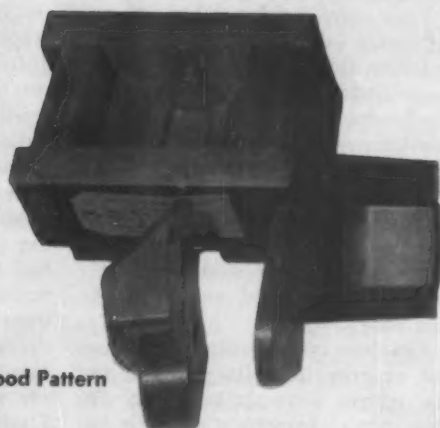
Metal Pattern



Iron Molding



Non-Ferrous Molding



Wood Pattern

Don't Sabotage Gray Iron Machinability

Keep your competitive advantage by avoiding:

- 1) *Improper cupola melting practices,*
- 2) *Contaminated raw materials,*
- 3) *Incorrect carbon equivalent,*
- 4) *Uncontrolled cooling rates.*

by MORRIS GITTLEMAN
Foundry Consultant
Los Angeles

GRAY IRON machinability inherently depends on foundry practices that influence the casting microstructure. In order of increasing hardness, the important micro-constituents of gray iron are: 1) graphite (Bhn negligible), 2) ferrite (100-140 Bhn), 3) pearlite (200-250 Bhn), 4) steadite (350-550 Bhn), and 5) carbide (600-800 Bhn). These micro-constituents are shown and identified on page 48 of this issue.

Graphite is the softest constituent of gray iron. Its presence in the matrix accounts for many of gray iron's characteristics, such as ease of machinability. For any given

composition, the amount of graphite formed, its flake size and distribution are primarily dependent upon cooling rate, heat transfer during solidification, and subsequent phase transformations.

These graphite flakes are the excess carbon which cannot be held in solid solution in gray iron. Under varying compositions and cooling rates, they occupy positions within the framework of the primary formed dendrites and assume definite patterns within such structure, some more favorable than others with respect to machinability. During machining these graphite flakes serve as discontinuities with-

in the relatively hard matrix, helpfully breaking up the chips and acting as a lubricant. Slow cooling favors abundant, large and well distributed graphite flakes, which improve machinability.

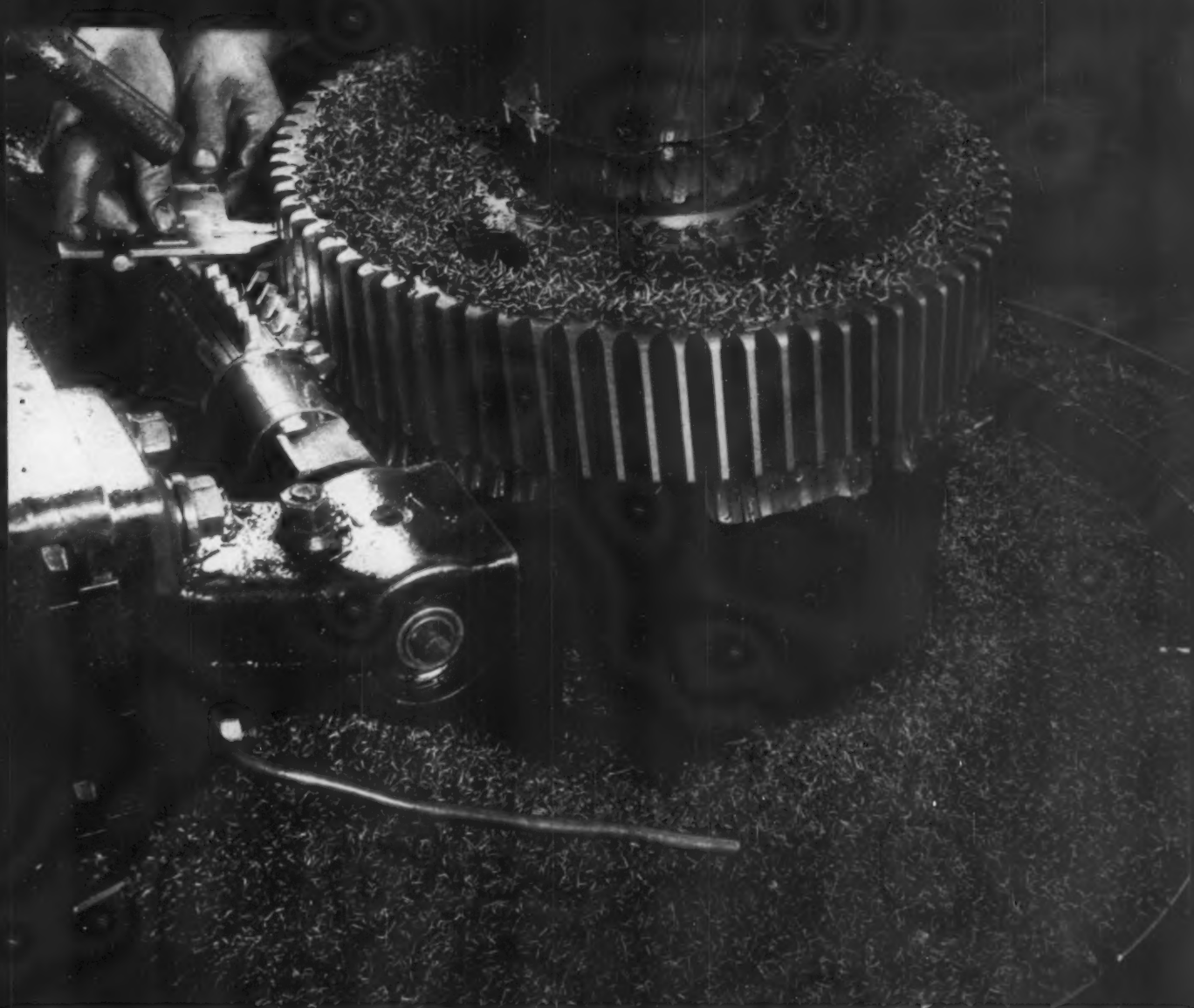
Graphite flakes can be visualized as curved miniature leaves or flower petals of varying sizes, randomly dispersed in a cake of frozen ice, occupying approximately 10-12 per cent of the volume but only about 2.5-3.0 per cent of the weight. Now if we change these twisted leaves or flower petals back to graphite and transform the surrounding ice to steel you have a rough picture of gray iron's structure.

Ferrite and Carbide

Ferrite is a solid solution of silicon in alpha iron. It is stable at room temperature, magnetic, fairly strong, soft, and ductile. Under specific conditions, ferrite forms from austenite, from pearlite, and from iron carbide. Factors usually promoting graphitization also favor the formation of ferrite. Although free ferrite in gray iron lowers strength, hardness and wear properties, it greatly improves machinability. Free ferrite can be expected in gray iron when the combined carbon is below 0.5 per cent. The presence of this soft ductile ferrite in association with the chip-breaking graphite flakes makes for excellent machinability of gray iron.

Iron carbide (Fe_3C) is an extremely hard constituent which seriously impairs the machinability of gray iron to the extent of its presence. White or mottled fractures are indication of the presence of free carbides in the structure. Composition and cooling rate determine its presence or absence.

Pearlite is a mixture of alternate layers of ferrite and iron carbide (Fe_3C) or cementite. It is strong and moderately hard. The matrix of gray iron is usually rendered completely pearlitic with cementite in the range of 0.50-0.85 per cent, depending upon chemical composition. Most normal gray irons approach this structure. Depending upon composition and cooling rate, pearlite varies from coarse to fine lamellae formations. Slow cooling promotes the coarse variety which in turn produces the weaker, softer and more machinable iron.



Good machinability of gray iron pays off on jobs like this.

When the combined carbon is less than that required to produce a completely pearlitic matrix, then free ferrite is formed and an easy to machine iron results. When combined carbon exceeds that needed to establish a full pearlitic matrix then primary or massive cementite forms. This structure is very detrimental to machinability.

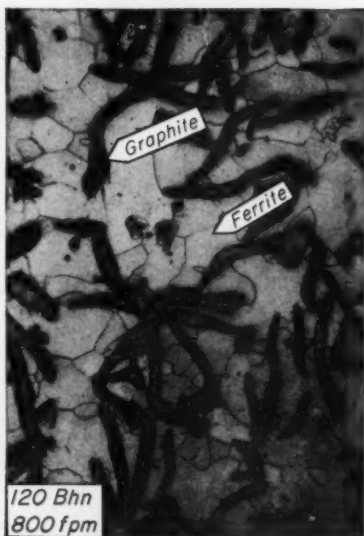
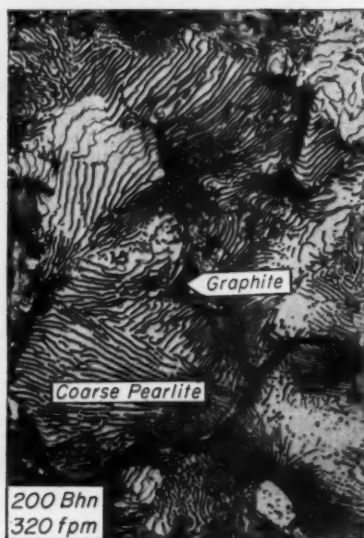
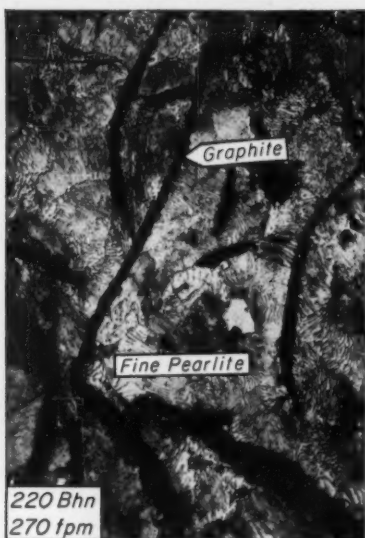
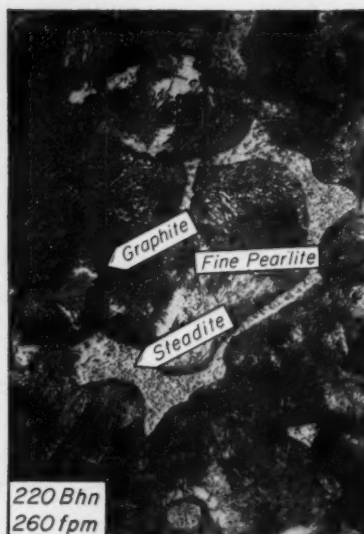
A pearlite matrix with graphite flakes distributed throughout represents the most common gray iron microstructure. Too fast a cooling of normal gray iron castings brings about a mottled structure—consisting of a pearlitic matrix, iron carbide, and graphite. This iron is difficult to machine. If we should reduce substantially the carbon and silicon contents in the above cast-

ing and maintain the very rapid cooling rate, the structure of the resulting metal would be white. Such structure consists of a pearlitic matrix, no graphite, and a large percentage of iron carbide; it is completely unmachinable.

Steadite in gray iron is a eutectic structure of iron, carbon, and phosphorus. Because of its low melting point, steadite concentrates in the last areas to solidify, outlining the eutectic cells at their boundaries. Steadite is a rather hard constituent of gray iron and also tends to decrease graphitization. So for best machinability, keep phosphorus as low as possible. There appears to be no substantial impairment of machinability with phosphorus under 0.3 per cent.

With so many possible variations of microstructure for any given composition, the problem becomes finding a range of structures in which the machinability requirements of a specific group of castings can be reasonably secured. The practical foundryman can and should understand the extent to which his foundry practices are detrimental or conducive to the production of castings with good machinability.

Let's begin with a metal composition that is held within a desired range. Check this regularly by chemical analysis and make appropriate adjustments in the mix to stay within limits. Elements found in gray iron can be classified according to their effect on machin-



ability. Carbon and silicon strongly favor graphitization and the establishment of those structures that are easy to machine.

Manganese, phosphorus, and sulphur tend to produce the opposite condition. Alloying elements used in gray iron may be similarly labeled; vanadium and chromium are powerful carbide stabilizers that restrain graphitization; aluminum and titanium act to soften the structure. Some elements like boron or tellurium have such drastic hardening effects that their presence to any extent in machinable gray iron is highly undesirable.

Cupola Influences

Many practices related to the cupola melting operation significantly affect the final structure and machining properties of gray iron. Some of these are:

1) In general, iron is softened by using high-carbon coke of proper size and strength, uniform and substantial coke bed, moderate melting rates, low metal to coke ratios, and high spout temperature.

2) Uniform melting rates, steady temperatures at the spout and satisfactory chill readings are usually indicative of a stable, machinable metal composition. Moreover, a fully and correctly charged cupola at constant air input, accompanied by a fluid, bottle-green slag, can go a long way to produce this desirable metal.

3) A dark brown or black slag, generally accompanied by sparking, indicates excessive metal oxidation and hard to machine castings. This condition is usually caused by a low coke bed, incorrect or insufficient charging, and excessive wind input.

4) Raw materials for the cupola charge should not only be correctly weighed but also properly sized. Unusually small pieces tend to melt high in the cupola, causing uneven combustion and composition. Likewise, excessively large pieces, such as scrap, melt too low in the cupola, producing lower temperatures and smaller carbon pickup.

5) Raw materials should be reasonably rust free. Rusted or burned pieces favor metal oxidation during melting. Scrap possessing tramp elements or unusual carbide stabilizers should not be charged. The presence of non-ferrous metals or

steel in the charge, tends to lower carbon and promote oxidation. When motor blocks are a substantial part of the scrap used in the charge, care should be taken to hold the chromium content of the castings to a maximum of 0.10 per cent. Although aluminum tends to soften the gray iron matrix, its presence in light section castings such as pipe fittings can cause pinholes as well as fluidity impairment.

6) Refractory linings of the cupola and ladles should be thoroughly dry. Wet linings release gases into the molten metal, producing hard carbides, high chill, and subsequently hard to machine castings.

7) The silicon content of iron at the spout should run 0.2-0.4 per cent below the final desired. Then compensate for this deficiency by an addition of ground ferro-silicon to the spout or ladle. This practice allows more solution of carbon while iron is in the cupola. The late addition of properly sized ferro-silicon not only makes up the silicon deficiency but also improves the graphite size and distribution. These combine to markedly improve the machinability of iron.

8) Inoculation involves the addition of fine granular material such as graphite, crushed ferro-silicon, calcium-silicon, silicon-manganese-zirconium, and a host of other products to molten gray iron, preferably above 2700 F. This practice promotes a desirable graphite formation through nucleation of solidification centers, deoxidizes the molten metal, reduces chill and section sensitivity, and improves fluidity.

9) Pouring is an important foundry operation. Pouring stream should be steady and uninterrupted, keeping the sprue full. Dribbling metal into a mold can lead to misruns, cold shuts, and difficult to machine castings. The practice of returning for a refill at the cupola with cold unpoured metal in the ladle should be discouraged.

Two Simple Tests

Two simple tests are available for proving the effectiveness of your metallurgical practices:

1) Standard chill specimens, taken hourly, are good indicators of over-all composition and machinability. Chill specimens measuring a 2/32-inch chill and under can be considered to represent metal

of suitable machinability for gray iron of 1/8 to 1/4-inch section. To the extent that the chills measure in excess of that figure, the corresponding castings will be increasingly more difficult to machine.

2) The Brinell hardness test offers another method for checking machinability trends of metal castings. A cylindrical test bar of 7/8-inch diameter and 12-inches long (ASTM) should be poured under uniformly reproducible conditions. The hardness reading should be taken on a disk approximately 1/2-inch thick, cut from the central portion of the bar. Such Bhn readings taken once or twice a day will more truly represent the average hardness of the metal than similar tests on castings subjected to many cooling and pouring variables. A range of hardness readings can then be correlated with generally satisfactory casting machinability.

Cooling Rate Influences

Because the rate of cooling critically affects the structure of gray iron, the heat transfer conditions surrounding casting solidification have an important bearing upon casting machinability. Significant factors controlling cooling rates of castings are:

1) Cast metal section:—The thinner the metal section the more rapidly it cools. Fast cooling encourages hard carbide retention and consequent difficult machining. The thicker the metal section of the casting the slower is the cooling rate and the softer the metal structure. It follows, therefore, that the thinner the cast section, the more carbon and silicon is needed in the gray iron to produce a machinable structure.

Under normal conditions 1/8 inch is the minimum castable section in gray iron. A gray iron composition to match the cooling rate imposed by the thinnest castable section, 1/8 inch, approaches a carbon equivalent of 4.3. Carbon equivalent = % carbon + 0.3 (% silicon + % phosphorous). Thicker sections normally need proportionately smaller carbon equivalents to form gray structures. For castings with sections of 3/16 – 5/16 inch, good machinability will be achieved with the following composition: 3.45% C; 2.40% Si; 0.65% Mn; 0.20% P; and 0.11% S. This iron possesses a carbon equivalent

of 4.23, is gray throughout and machines well.

Cast in sections less than 1/8 inch this same metal is hard to machine. On the other hand, a carbon equivalent of 4.10 would be adequate for larger castings with a machinable section of 1/2 inch.

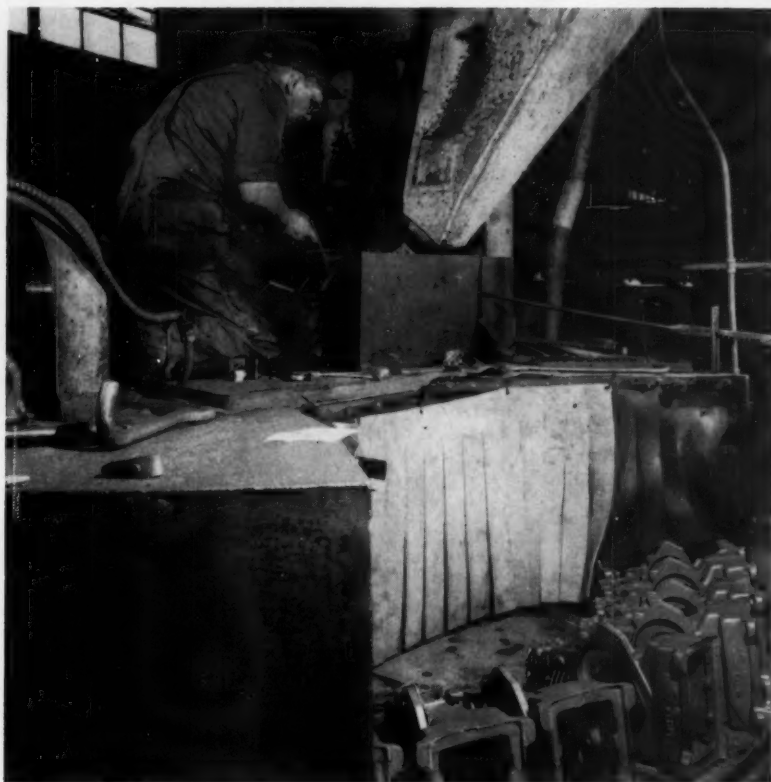
2) Volume to area ratio:—In evaluating cooling rates of metal sections or castings, the volume to one. The larger the ratio of metal area relationship is an important volume to the surface area in contact with the mold, the slower is the cooling rate. And the smaller this ratio, the more rapid is the cooling rate.

3) Mold conditions and heat transfer:—By the use of specific mold or core materials, cooling conditions can be controlled more or less favorably. Heat conductivity of a mold or core varies with rammed density, content of moisture and carbonaceous materials, type and amount of binders, surface washes, sand to metal ratio, etc. Thus mold materials can be selected and blended to help control the cooling rate of castings.

Furthermore, heat can be removed by direct chills contacting castings or by indirect chills located behind a thin layer of sand. In addition, two other important heat transfer phenomena take place in the mold: radiation from the metal directly onto mold surfaces and convection of hot gases through mold vents.

4) Shakeout time:—The removal of heat from castings in sand molds is a relatively slow process compared to cooling them in air. Machinable castings should not be shaken out red hot. Such an "air quench" from above 1300 F produces harder gray iron structures than obtained when cooled in mold below 1000 F. The shakeout of production machinable castings should therefore be timed so that they cool in mold at least below 1000 F.

Machinability, to the extent of its requirement, is an important casting property. Usually the optimum possibilities of one property such as machinability must be sacrificed in order to accommodate others, such as strength or hardness. The control of foundry practices so the resulting castings are endowed with the required properties offers the best assurance for the manufacture of a competitive product.



How to Make Your Cleaning Equipment Last Longer

by EDWARD SCHLIES

You can save money by following a regular procedure of care. Recommended are:

- 1) Rest-period checks.
- 2) Week-end major repairs.
- 3) Lunch-period inspection.
- 4) Vacation overhauls.
- 5) Daily lubrications.
- 6) Twice-a-week abrasive metal examinations.

This plan pays off for the Brillion Iron Works. Good records are essential, points out Brillion's plant engineer.

THANKS TO an effective preventive maintenance program, Brillion Iron Works, Inc., Brillion, Wis., successfully maintains relatively high operational efficiency on two pieces of airless blast cleaning equipment that are sixteen and seventeen years old. One is a table-blast and the other a tumble-blast machine.

Brillion Iron Works is a large and modern gray iron jobbing foundry, producing a wide variety of castings, including many intricate shapes. The daily output is approximately 120 tons, of which 90 per cent or more are jobbing orders. The balance are parts used in a line of farm machinery manufactured by Brillion. For about four months of the year, the plant runs three shifts, twenty-four hours a day, five days a week. The remaining eight months it generally operates two shifts, sixteen hours a day, five days a week.

With production schedules this demanding, careful and frequent inspection is a sensible investment to discover and correct minor problems before they reach major proportions and possibly interrupt production.

Both pieces of blast equipment have wheel-hour meters to record actual hours of blasting time. On a three-shift day, the table-type blast machine shows an average production of 20 to 22 hours daily. The tumble-blast records an average of 14 wheel-hours a day.

Six Maintenance Practices

Here are six preventive maintenance measures that keep Brillion's cleaning department operational round-the-clock;

1. During the 10-minute rest period at 9:00 A.M., a mill room service man checks both machines—a quick inspection of blades, adjustment of shot spout, and other minor matters that can be handled in a short time.

2. During the lunch period from noon to 1:00 P.M., the same mill room service man makes a somewhat more extensive check of both machines, making adjustments and minor repairs. Activities might include changing of a wheel housing liner, adjusting the elevators, welding in a wear plate, or installing a new liner. This noon-day check is thorough enough to assure reliable equipment performance through the night shift. Generally, there is no maintenance check on the cleaning equipment during the third shift.

3. On week ends, major repairs are made to the equipment, such as replacing liners, more extensive repairs to elevators, replacing curtains and other work that would take the equipment out of service for more than a few minutes of production time. When the plant is on two-shift operation, these repairs sometimes are done at night rather than on week ends.

4. Once a year, during plant vacation shut-down, both machines are completely overhauled. Any work too extensive for a week end project generally is done at this time. Such projects seldom occur again during the production year. The apron on the tumble-blast is replaced at this time, for example. Channel irons

under the table are replaced and all cabinet liners are replaced during this overhaul.

5. Lubrication is done every day early in the morning without shutting down the equipment. All lubrication points, including pillow block bearings on the wheels, are lubricated with a pre-determined amount and type of lubricant.

6. Abrasive metal shot is checked twice a week with screens as recommended by the manufacturer and the separator is adjusted accordingly. The discharge from the separator also is screened and adjustments made as necessary to avoid withdrawing usable abrasive from the machine.

Lou Johnson, superintendent of maintenance for Brillion, points out this system of inspection and repair has been established gradually over a period of years so that cost comparisons in maintenance show little that is spectacular in savings from one year to the next.

However, he reports, the steady progress does add up to spectacular savings. For instance, at one time blade life was as low as 24 wheel-hours per set of blades. Since instituting the practice of screening the separator discharge and the abrasive mix regularly, Brillion has been able to bring the average blade life up to 239 hours per set of blades, an increase of 900 per cent!

Pillow block bearings provide another instance. They once were burned out and replaced on an average of 3 to 4 times a year. Since regular lubrication practice has been instituted, this problem has become insignificant. The last set of bearings lasted 4 years.

Keep Good Records

The fact that such figures as those quoted above are available points up the existence of adequate records. Good record-keeping provides a measuring stick of progress. Here is the procedure followed at Brillion:

1. Once a week, following one of the mid-week inspections and servicing of equipment, a written report is submitted to the superintendent of maintenance. The report forecasts repairs and parts' needs during the following week, based on the condition of the

During one-hour noon shutdown, blades in abrasive blast wheel may be replaced.



parts and equipment at the time of this inspection. With such a control you can be sure that the necessary replacement parts are on hand, and schedule any extensive work that may be required.

2. A perpetual inventory of replacement parts is maintained on file cards in the tool room. These indicate minimum and maximum quantities to keep on hand, based on average usage of such parts. A 30-day stock of all repair parts (blades, liners, bearings, curtains, etc.) is kept on hand to avoid shortages and delays in maintenance and repairs.

3. As parts are withdrawn from stock, the stock room issues a withdrawal card which is tabulated by IBM equipment along with job time involved in installing the parts.

4. The plant engineer receives weekly IBM reports showing the number of maintenance hours, the maintenance labor cost, the parts installed, the cost for parts, and the total maintenance cost for each machine.

In addition to providing a complete service and maintenance cost record, these reports also serve to pinpoint changing maintenance problems. Remedial action can then be taken before costs become excessive. Stock room records also serve as an easy check on parts life for establishing adequate inventory without overstocking and tying up unnecessary capital.

The Maintenance Crew

Johnson points out, "It is not enough to know good maintenance procedures, it is necessary to practice them." He places great importance on the caliber of the maintenance crew assigned to the project and feels that much of the success of the maintenance program at Brillion is the result of having a crew of able and conscientious machine maintenance men.

The maintenance crew at the plant includes 26 machine repair men under Johnson's supervision. In addition, there are a number of helpers, oilers, and general laborers who also are assigned to this department.

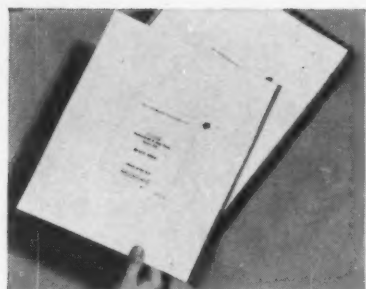
Of the qualified 26 machine repair men, 19 are on day duty at present and 7 on night duty. This varies with the number of shifts on which the plant is operating. Four of the machine repair men are thoroughly trained to service blast cleaning equipment. One man is assigned permanently to mill room repairs.

When a new maintenance man works on the blast cleaning equipment he is given operating manuals, instructions on what he should inspect, and a routine to follow. He works with an experienced maintenance man for about a month, during which time he sees at what condition of wear the company wants to replace various parts.

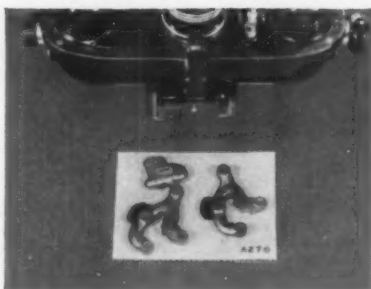
The evidence of the success of the preventive maintenance program at Brillion Iron Works is found in the fact that equipment 16 and 17 years old is still operating to Brillion's satisfaction. By practicing sound and effective maintenance, this firm is utilizing equipment which might otherwise have to be replaced in order to keep pace with the needs of their production.

Rate of usage of blast cleaning equipment wear parts are recorded on the forms shown above and below. The maintenance man's weekly repair forecast, above, forms part of the basic control in preventive maintenance at Brillion Iron Works.

Stock room inventory cards provide additional control.



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S. C. Massari

Castings Congress Papers

Here is your monthly preview of Castings Congress Papers. Nine important technical articles unfold new metalcasting horizons. A diverse array of subjects is covered—arc melting, stainless steel, work measurement, nickel carbonyl patterns, hardenability of malleable iron, management by objective, casting titanium, gray iron inoculation, sand design, and precision casting mold materials.

TECHNICAL HIGHLIGHTS

Stainless Steel Arc Meltingp 55

This point-by-point countdown tells the operating foundryman how to line his furnace, prepare his charge, melt, slag, and alloy the steel.

Work Measurement for Pour and Shakeout ...p 58

Here is an industrial engineering approach used in a work measurement plan for a nonrepetitive jobbing foundry operation—pour and shakeout. The plan resulted in a 20-per cent increase in performance level of pour and shakeout workers and a 20-per cent increase in workers' earnings.

Nickel Carbonyl Pattern Equipmentp 65

This new process introduces an entirely different technique for producing exceptionally accurate patterns. Metallic nickel is deposited onto a master pattern negative from an atmosphere of nickel carbonyl. These patterns have high abrasion resistance and can be welded, brazed, and soldered.

Hardenability of Mn-Mo Pearlitic Malleable ...p 69

The hardenability of malleable iron determines the section thickness which can be successfully quench-hardened for optimum properties. The addition of 0.18-0.25 per cent molybdenum and 0.36-1.33 per cent manganese provides a wide range of hardenability and extends section size limitations.

Management by Objectivep 71

Management must first establish operating objectives, together with control and evaluation procedures to implement progress in each specific area. The author tells how to use variance reports, budgets, and man-hour per ton indices to achieve organizational objectives, safety, quality improvement, and cost reduction.

Casting Titanium Ordnance Partsp 76

Titanium castings are getting bigger. To meet size requirements Frankford Arsenal designed and built a 110-pound capacity, consumable electrode, arc-type, vacuum furnace. A titanium alloy containing 6-per cent aluminum and 4 per cent vanadium was cast into both machined and rammed graphite molds. Without heat treatment the castings achieved 135,000 psi ultimate tensile strength, 120,000 psi yield strength, and 11 per cent elongation.

Inoculation Effect on Gray Iron Riserp 83

Larger risers are needed on inoculated gray iron because of increased mold wall movement due to a more mushy-type solidification combined with a finer eutectic cell size. This combination produces a greater eutectic graphite push against a casting wall that is weaker for longer periods.

Sand Design and Controlp 94

Foundry sand technology today lacks the ability to assign numerical values which can accurately describe sand quality and condition. This first study of a series dwells on the major variables encountered in simple clay-sand-water systems. When the study series is complete, foundrymen will have available to them basic knowledge required for engineering foundry sands.

Precision Casting Mold Materialsp 109

A ceramic engineer explains the how and why of refractory mixes used for investment casting molds. Mixes must have high temperature stability, harden in controlled period of time, be simple to mix, show minimum dimensional change, and be economically practical.

The AFS Castings Congress papers are the most authoritative technical information available to the metalcasting industry. Over 100 papers were prepared by close to 250 authors and presented at the 1960 Congress in Philadelphia, May 9-13. Papers receive preview publication in *MODERN CASTINGS* and then are bound into the annual

volume of AFS *TRANSACTIONS* for permanent reference. All papers have been approved by the appropriate Program and Papers Committee of the sponsoring AFS Technical Division. They are then edited by AFS staff members C. R. McNeill and M. C. Hansen. Written discussion of these papers will be welcome.

STAINLESS STEEL ARC MELTING PRACTICE

by S. E. Wolosin

ABSTRACT

A great deal of investigation has been reported on the influence of the various parameters in stainless steel making. The development of any practice for a particular shop becomes a compromise of the many influencing factors consistent with control, quality, and reproducibility.

This paper is a discussion of the equipment employed in arc melting stainless steel at the author's company, the basic considerations upon which the practice was developed and the practice itself.

INTRODUCTION

The author's company has two 8 ft shell, top charge arc furnaces powered with 2500 kva transformers having a 13,700 volt primary. Secondary voltages range from 235 on the no. 4 tap to 118 volts on the no. 1 tap. Average melts are from 4 to 5 tons. A single slag basic practice and decarburize with metallurgical oxygen is employed.

The furnaces are lined with a burned magnesite brick subhearth which is carried up to the slag line. The working hearth is a rammed 66 per cent MgO bottom. Above the slag line, the sidewalls consist of steel clad unburned periclase-chrome brick (65 per cent MgO—9 per cent Cr_2O_3). At the present time experimentation is underway on a revised roof practice employing high alumina compositions.

Most of the common stainless steels are regularly made in the arc furnaces, including the 0.03 per cent maximum carbon grades. However, in this discussion, we shall consider the processing of the Type 304 (CF-8) stainless grade.

BASIC CONSIDERATIONS

Some basic considerations that have guided the company in the development of the practice have been:

- 1) The higher the chromium content in the initial charge, the higher the temperature that must be attained in order to reduce the carbon to low values.¹ It has been shown that the activity of oxygen and of carbon is inversely proportional to the chromium concentration.²
- 2) The higher the bath temperature before and after the blow, for a given rate of oxygen input, the less metallics oxidized to the slag, hence the lower the volume of slag generated.¹

- 3) The higher the bath temperature at the end of the blow, the lower the carbon can be reduced for the same chromium content in the bath.³
- 4) The higher the rate of oxygen input a) the shorter the oxygen blowing time, b) the less oxygen consumed, c) the less metallics oxidized to the slag, d) the faster the decarburization and e) the higher the bath temperature at the end of blow.⁴
- 5) A good vigorous carbon boil is beneficial in reducing hydrogen.^{5,6}
- 6) The bath is subject to gas pickup when held under a strongly reducing atmosphere,⁶ or when additions are made which are not completely dry or free of moisture.⁷
- 7) Basicity ratios of 1.4 to 1 minimum, closely approach the practical operating optimum for chromium recovery.^{9,10,11}
- 8) Magnesite bottoms are subject to accelerated erosion when held under highly oxidizing conditions at elevated temperatures.¹²
- 9) Large slag volumes are difficult to work effectively.¹³

Bearing these relationships in mind, and based upon a series of data developed from experimental investigation on a series of production heats, the following practice has been developed as an effective operating approach, compatible with the purely theoretical considerations.

The amount of chromium in the initial charge is aimed at 13 per cent. Heats are melted in with a 0.50 per cent minimum carbon in order to provide for a good vigorous boil. Temperature at the start of the blow is controlled to 2900-2950 F (1593-1621 C) immersion thermocouple reading. Oxygen blowing rate is 250 cu ft/min with a line pressure of 150 psi using a 1/2-in. refractory coated lance. Oxygen input is closely metered and controlled. All lime additions are made to the bath before the blow and slag basicities are controlled.

FURNACE CHARGE COMPOSITIONS

Standard furnace charge compositions have been developed for each of the stainless types produced, and a typical example for Type 304 (CF-8) is shown in Table I.

The required amount carbon, ore and 240 lb of the total lime specified for the heat weight are added to the initial charge in the furnace. The balance of

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Fig. 1 — Blowing heat with oxygen.

TABLE 1 — TYPE 304 (CF-8) ARC FURNACE CHARGE COMPOSITION PER 1000 LB HEAT CONTROL

Type 304 revert scrap, lb	580
Electrolytic nickel, lb	36
Carbon steel plate, lb	250
Low carbon ferrochromium, lb	85
Ferrochrome silicon, lb	65
Coke braise, lb	6
Lime, lb	75
Ore, lb	11
Oxygen, cu ft	225

the required lime is added during melt-down and before the blow. The chromium balance is made by additions of FeCrSi (39 per cent Cr-42 per cent Si) and low carbon FeCr, figuring 95 per cent recovery for the element. All the nickel requirement is added to the initial charge. Typical melt-down analyses are shown in Table 2.



Fig. 2 — Checking preliminary on direct reading spectrometer.

TABLE 2 — TYPICAL MELT-DOWN BATH SAMPLES

	Heat No.		
	E-980	W-3259	E-1076
Carbon, %	0.51	0.51	0.50
Manganese, %	0.55	0.51	0.56
Silicon, %	0.28	0.19	0.18
Chromium, %	13.23	13.09	12.99
Nickel, %	10.90	11.19	11.21

When the bath temperature reaches 2900-2950 F (1593-1621 C) the oxygen lance is inserted (Fig. 1). It is held about 3 in. below the slag-metal interface, while being constantly moved around the surface until the specified amount of oxygen is injected. Should the bath activity in the melter's opinion indicate that some additional blowing time is necessary, he is free to add more. Rarely, however, is more than 200 to 300 cu ft of additional oxygen added. Typical slag analyses after the blow are shown in Table 3.

TABLE 3 — TYPICAL SLAG SAMPLES AFTER BLOW

	Heat No.		
	E-980	W-3259	E-1076
FeO, %	11.45	9.94	15.10
MnO, %	2.21	2.20	2.50
Cr ₂ O ₃ , %	37.44	32.99	39.20
CaO, %	32.48	34.94	31.14
SiO ₂ , %	9.78	11.26	7.16
MgO, %	5.32	6.16	4.59

Immediately after the oxygen blow, the specified amounts of the chromium alloys are added to the bath. The FeCrSi is added first in order to reduce the high FeO level of the bath and slag, and to thus insure the ready solubility and recovery of the added chromium.

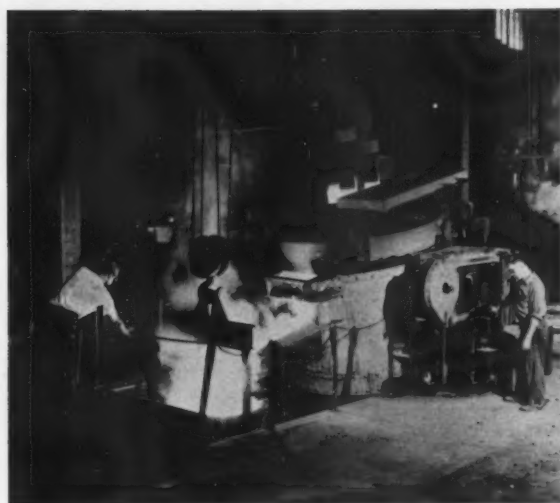


Fig. 3 — Tapping the heat.

FERROCHROMIUM ADDITION

The low carbon FeCr addition follows immediately, and due to the elevated temperature of the bath at this point (in excess of 3300 F) the alloys readily go into solution. These additions also serve to sharply reduce the temperature of the bath, hence, minimize the exposure of the bottom to strongly oxidizing conditions under extended elevated temperatures.

The processing of the heat is not delayed to run a carbon preliminary test. After the chromium additions are made, the bath is rabbled well and the slag is given an opportunity to come to equilibrium. After about 10 min it is rabbled well again, and a preliminary spectrometer sample is taken (Fig. 2). Typical preliminary samples are shown in Table 4.

TABLE 4 — TYPICAL SPECTROMETRIC PRELIMINARY RESULTS

	Aim	Heat No.		
		E-980	W-3259	E-1076
Silicon, %	1.25	1.03	1.21	0.83
Manganese, %	0.45	0.71	0.44	0.44
Chromium, %	18.00	18.00	18.80	17.80
Nickel, %	9.00	8.87	9.77	9.40

After the preliminary result has been returned, minor alloy adjustments are made to the furnace, the temperature adjusted and the heat is tapped (Fig. 3) into the ladle with an addition of FeSi made to the ladle. Typical final bath samples are shown in Table 5. Typical final slag samples are shown in Table 6.

A recent gas analysis of some stainless steel heats made in accordance with the described practice is shown in Table 7.

Fundamentally, what the author's company has tried to develop has been a reproducible practice that insures good bath action, purging of hydrogen, minimum slag volume, minimum oxygen consumed, minimum bottom delays, with good compositional control in minimum furnace time.

TABLE 5 — TYPICAL FINAL BATH SAMPLES

	Aim	Heat No.		
		E-980	W-3259	E-1076
Carbon, %	0.07 max.	0.046	0.054	0.052
Silicon, %	1.35	1.11	1.28	1.36
Manganese, %	0.75	0.73	0.80	0.82
Chromium, %	19.00	18.45	18.56	19.03
Nickel, %	9.00	9.32	9.77	9.12
Phosphorus, %	0.04 max.	0.018	0.018	0.017
Sulfur, %	0.05 max.	0.016	0.017	0.020
A.S.T.M. Specification A296				
Yield Strength, psi	28,000		34,000	35,000
Tensile Strength, psi	70,000		74,000	79,000
Elongation, %	30.0		50.0	52.0
Solution Treatment: 2050 - 2100 F W. Q.				

TABLE 6 — TYPICAL FINAL SLAG SAMPLES

	Heat No.		
	E-980	W-3259	E-1076
FeO, %	2.30	1.01	1.08
MnO, %	1.16	0.90	1.33
Cr ₂ O ₃ , %	3.32	2.62	3.92
CaO, %	41.66	43.23	43.20
SiO ₂ , %	34.76	37.48	40.40
MgO, %	14.92	12.74	9.54
B.R.*	1.63	1.49	1.31

$$\text{*Basicity Ratio} = \frac{\% \text{ CaO} + \% \text{ MgO}}{\% \text{ SiO}_2}$$

TABLE 7 — TYPICAL HYDROGEN CONTENTS

Description of sample	Hydrogen Content p.p.m.
Before oxygen blow	5.0 - 5.5
After oxygen blow	0.7 - 2.3
At tap	2.9 - 3.3
From ladle	3.5 - 3.8

ACKNOWLEDGMENT

The author wishes to thank the management of the Lebanon Steel Foundry for permission to publish this paper. Special acknowledgment is due also to Messrs. W. A. Koppi, W. W. Englehart, J. Bodenhorn and G. Chabitnoy, without whose excellent cooperation the described practice could not have been developed.

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WORK MEASUREMENT FOR POUR AND SHAKEOUT

by R. S. Casciari

ABSTRACT

This is a discussion of the industrial engineering approach to the development of a work measurement plan for a highly varied foundry operation; namely, pour and shakeout. The term "work measurement" has many connotations to different people. Depending upon experiences, positions or what has been heard or read, it could suggestively signify labor problems and higher costs or higher productivity and lower costs. To the industrial engineer it is one of management's most important tools, some form of which can be used to improve productivity in any kind of manufacturing operation.

Through the use of today's newer industrial engineering techniques, work measurement can be developed on a more practical basis to cover the operations which have long been classified as unmeasurable. The pour and shakeout operation in the jobbing foundry is nonrepetitive and highly variable. It also has some restrictions which affect the overall time to perform each function in the operation. These factors have long been problems to those who have attempted to measure this type of work.

The author's company's approach to the solution of this problem was a practical one. In this discussion the purpose of the study will be discussed by defining the problem, describing the operation through the use of a layout illustration, the development of methods and specifications, the use of the newer techniques of industrial engineering such as the group timing technique, the development of standard data and the illustration and application of the work measurement plan. The results obtained will be shown in the performance graph illustration.

PURPOSE

The purpose here is to present an industrial engineering approach used in the development of a work measurement plan for a nonrepetitive jobbing foundry operation; namely, pour and shakeout.

For many years the industrial engineering techniques have been applied primarily to the direct repetitive type operations. The degree of success which has been achieved was determined by the ability of the industrial engineer developing the standards and the integrity of the company. In most cases, the application of sound industrial engineering principles to production work has improved productivity where they were properly applied.

The indirect nonrepetitive type operations were

often neglected. In some cases incentive plans have been applied to indirect operations based on historical data and ratios or percentages. Some of these did not measure the amount of work and were for the most part unsuccessful.

Recently the industrial engineer has developed new and usable statistical and mathematical tools which he can use to expand his work measurement applications. They can be used to measure the work in the indirect nonrepetitive type operations.

In an incentive company neglect of the indirect operations usually causes problems of inequities. Differences in wages between the incentive and non-incentive worker has caused dissension and differences in their performance levels. Reduction of direct costs have made the comparison between direct and indirect costs more pointed. For these reasons most companies have been forced into considering a work measurement program for these indirect operations.

PROBLEM

The pour and shakeout operation presented this type of problem in the author's company. The differences in the performance levels between the pour and shakeout workers and the molders created a bottleneck in the foundry work flow. The results were excessive lost time, higher costs and serious scheduling disruptions.

In evaluating this problem the conclusion was reached that what was needed was a technique to measure the time required to perform the pour and shakeout operation, and to develop work measurement standards for wage incentive application.

The fundamental principles which were established as guides in developing this program were:

- 1) Methods were to be simplified and standardized so that the work was performed based upon a clear understanding of both the human and material factors involved.
- 2) Observations were to be made in less time and at lower costs than had been the experience using the conventional time study technique.
- 3) Accurate work measurement standards were to be established simple enough for the workers to understand them.
- 4) The wage incentive application had to provide controls necessary to change standards whenever changes in the operation occurred.

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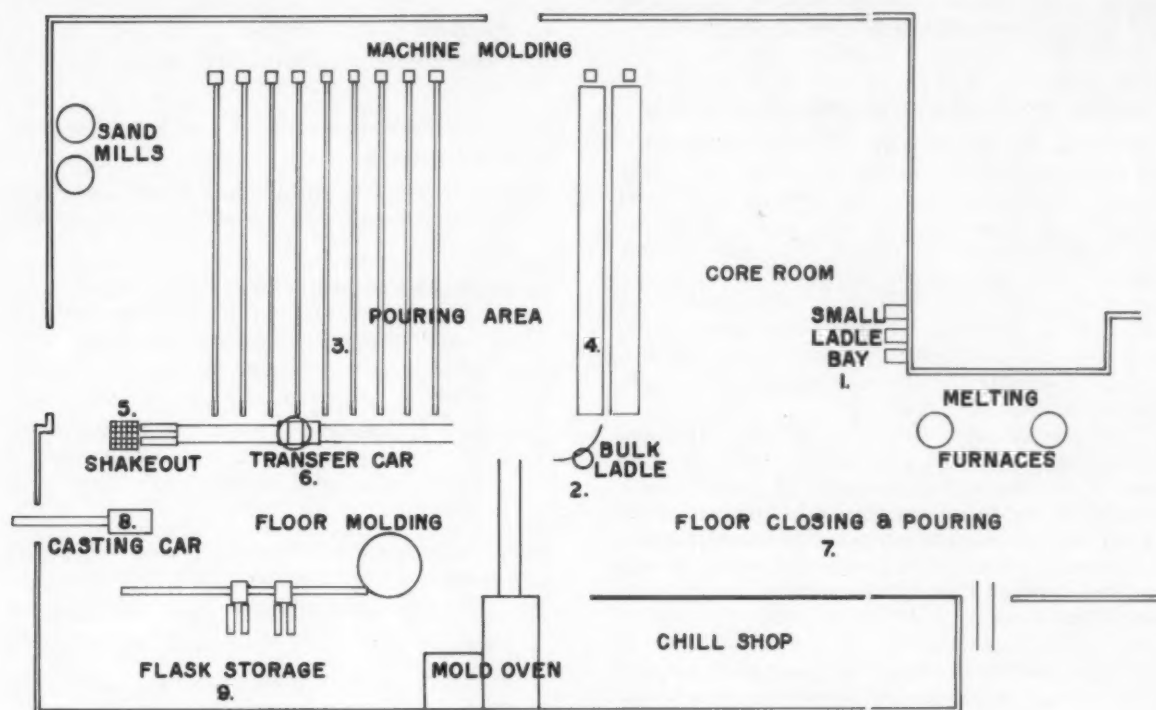


Fig. 1 — General foundry layout at the author's company.

GENERAL LAYOUT

Before proceeding into the details of the approach used, let us review briefly the physical layout of the foundry, as shown in Fig. 1, so that the operation may be understood more clearly.

Generally, this operation is performed by a crew of six men per shift. However, as the workload varies so does the crew size, usually from two to eight men per shift. Their functions include, pouring all machine molds, shaking out all machine and floor molds and maintaining a clean and orderly work area.

The pouring work cycle usually consists of:

- Obtaining proper ladle from ladle bay area (1).
- Transporting empty ladle to bulk ladle station (2) and obtaining molten metal.
- Transporting full ladle to either machine molding pouring area (3) where tight flask molds are poured, or to pouring area (4) where snap molds are poured. Ladles are transported by means of monorail carriage.

The shakeout work cycle usually consists of:

- Obtaining tight flask machine molds in pouring area (3) and pushing molds manually on roller conveyor onto transfer car (6).
- Transporting molds to shakeout unit (5) and pushing molds onto shakeout unit either manually or by overhead crane, depending upon mold size and design.

- Removing casting from shakeout unit with hand tongs, manually operated jib crane or overhead crane and asiding to tote box or casting car (8).
- Sorting all flask equipment and molding materials such as clamps, wedges, pins, bars, etc., and asiding to storage area (9).

The shakeout cycle is repeated for snap and floor molds with the following exceptions:

- Snap molds are obtained from pouring area (4) and manually dumped into tote boxes which are transported by overhead crane to the shakeout unit.
- Floor molds are obtained from the floor closing and pouring area (7) and transported to the shakeout unit by overhead crane.

The volume of work usually processed in this department on a per shift basis, generally ranges from four to nine shank heats poured and from 200 to 600 molds shaken out. The ranges in volume of molds are:

Machine molds — 1400 to 83,000 cu in.
Floor molds — 7500 to 580,000 cu in.

The examination of this type of operation confirms the conclusion that the work is subjected to great variations. Such factors as distance travelled, mold size and design, casting size and design, equipment and material usage, product mix, crane interferences and balance time necessarily have a sharp impact on the operation performance. Therefore, the decision was

to cope with this difficult problem by developing work measurement standards with the use of statistical methods.

WORK SPECIFICATIONS DEVELOPMENT

The first step was to simplify and standardize the operation as much as possible. It is a practice in the company that the industrial engineer and department supervisor develop the best method for doing the work before development of work measurement standards. As these methods are developed, the information is assembled and written in detail describing each element of work. These written specifications are a complete description or enumeration of the particulars concerning the operation methods, materials, equipment and related functions.

They provide a sound basis for simplification and standardization and aid considerably in the development, installation and maintenance of work measurement standards. Upon completion of written specifications, the workers are instructed in the application of the specifications. After a sufficient period, the operation is ready for study observations and development of standards.

Written specifications for the pour and shakeout operation include descriptions of such things as:

- 1) Pouring operating procedures.
- 2) Ladle handling.
- 3) Mold handling by size and type.
- 4) Casting handling by size and type.
- 5) Equipment and material operating specifications and actual use.
- 6) Work preference by crew size.
- 7) Equipment storage procedures.
- 8) Crane load specifications.
- 9) Shakeout temperature control.

As an example, the mold handling specification describes the transporting and shaking out of snap molds as follows:

- 1) Hook chains to container for snap molds (one man).
- 2) While overhead crane moves snap mold container to No. 16 or No. 17 machine conveyor two shakeout men walk to No. 16 or No. 17 machine conveyor.
- 3) Unhook chains from snap mold container.
- 4) Lifting with proper techniques, throw molds into snap mold container. Where the combined weight of metal and mold is greater than 100 lb, 2 men shall perform this operation lifting the same mold simultaneously. Maximum weight for

two men to lift simultaneously for this operation is 175 lb.

- 5) Throw bottom plate on floor northwest of No. 16 conveyor.
- 6) Repeat above operations (4 and 5) until rollout board is empty.
- 7) Man on west side asides rollout board, while man on east side pulls next loaded rollout board into position.
 - a) No. 16 Conveyor — Place rollout board on return conveyor. The first rollout board is placed upside down with the remaining boards placed right side up on top of the first board.
 - b) No. 17 Conveyor — Place rollout board on No. 16 conveyor for piling on return conveyor with same method as above after container is loaded.
- 8) Repeat operation 4 through 7 until snap mold container is filled (approximately 40 molds).
- 9) Pile plates on stacks and place the stacks of plates on piles of rollout boards on the return conveyor.
- 10) Hook up chains to snap mold container.
- 11) Overhead crane transports full snap mold container to storage conveyor at shakeout.
- 12) Swing chains under two rear corners of snap mold container so crane can dump container onto shakeout grid.
- 13) Swing chains under two rear corners of snap mold container for overhead crane to turn container over and move to storage north of casting car.
- 14) Unhook chains from snap mold container.
- 15) Aside castings into metal tote boxes. Use tongs to move castings under 40 lb pour weight, and use porter-bar for pour weights greater than 40 lb. Chill castings are not placed in tote boxes but are piled on the floor east of shakeout grid near the wall.

Follow this same procedure for tight flask molds on No. 16 and No. 17 conveyors, the flasks being placed in the snap mold container also. In operation 4 the cope section may be lifted separately from the drag because of the listed weight considerations.

STUDY TECHNIQUES

Our second step was to select a study technique which was both economical and accurate. Conventional timestudy was ruled out as a primary technique, because of the costly and lengthy process required to cover all of the variables in this operation. It was decided to use work sampling, a newer statistical work measurement technique. Work sampling

made it possible to study the operation in much less time and with fewer engineers and to determine exactly how many observations to make in order to expect the required accuracy. It provided the opportunity to get more details and facts of the overall operation cycle.

Two methods of work sampling were used. One based on random observations, and the other on a series of fixed interval observations. The latter which is called the group timing technique has some of the advantages of both timestudy and work sampling. It may be said that the group timing technique is part work sampling and part timestudy.

The random observation method was used primarily to determine percentage allowances. The group timing technique was used to observe the entire operation in order to obtain both elemental time values and allowances.

Three men were assigned to the study. One was responsible for the identification of each mold and for the recording of data pertaining to each mold. The molds were identified with large white chalk numbers. Corresponding to each number the following data were recorded: heat number; number and size of ladles; number of molds poured per heat; work station location; type and size of mold; pattern number; casting weight; mold volume. This information was used in the analysis of the study and development of the standards.

The mold identification number was recorded on the study sheet by the two observers and later used to identify corresponding data. Figure 2 is an example of this type study. Note that the observer made an observation every minute and recorded the number of men in the crew. He also utilized the rating procedure. Each study sheet covered one hr which was further broken down into 10 min time intervals. This illustration shows the shakeout elemental breakdown.

A similar type sheet was used to study the pouring elements. Two observers were necessary, because one observer could not see all the workers without spending a considerable amount of time walking from one work area to another.

In addition, timestudy was used to observe those miscellaneous elements of work which occurred infrequently. Direct standards were developed to cover this type of work.

DEVELOPMENT OF STANDARDS

After the indicated number of work sampling observations were analyzed, step three was proceeded with, and work measurement standards were developed through a system of averages broken down into the following units of measure:

Pouring

- 1) Number of heats poured.
- 2) Number and size of ladles used.
- 3) Number of test bars poured.

- 4) Number of double poured molds (molds which are poured using two ladles simultaneously).
- 5) Number of additional pours per mold (molds which contain two or more individual castings each poured separately).
- 6) Number of molds poured per heat.

Shakeout

- 1) Classification of molds shaken out (machine or floor—tight or snap flask).
- 2) Number and size of molds by volume.

Miscellaneous

- 1) Number of destroyed molds shaken out.
- 2) Number of gagger loads sorted.
- 3) Work area clean-up.
- 4) Number of molds transported to floor.

The standards for each shakeout unit of measure varied, dependent upon the number of men in the crew.

Allowances for personal, fatigue and delay were developed to cover the workers personal needs and delays. Delays such as crane interference, minor breakdowns, etc., up to 18 min per occurrence were included in the standard allowance.

APPLICATION OF STANDARDS

The fourth and final step in the approach was to develop an application procedure which would keep administrative cost down, and also maintain the control necessary for equitable incentive standards.

Two forms were designed for this purpose. The first is used to record the necessary heat information. A schedule clerk is assigned the responsibility of recording these data. Such things as starting and ending time of heat, number of molds poured, size of ladle used, etc., are part of the data recorded. Most of this information is used for scheduling purposes; therefore, data were obtained for standards application with little increase in administrative cost.

The second form was used by the timekeeping department. The shop timekeeper records information twice per shift. At the beginning of the shift he records the inventory of poured molds ready for shakeout. At the end of the shift he records the inventory of poured molds remaining for shakeout. Miscellaneous items of work are reported by the foreman to the timekeeper at the end of the shift.

This information, when accumulated with the information submitted by the schedule clerk, is all that is needed by the office standards clerk to calculate the performance index. An example of this form is shown in Fig. 3. The number of floor molds shaken out is reported on the back side of this form.

Standards are applied daily by shift on a group basis.

The calculations are simple and require little time, consequently performance index reports are in the

DATE: May 29, 1959

TIME: 10:00 A.M. TO: 11:00 A.M.

TALLY RECORDED EVERY MINUTE

OPERATION: POUR & SHAKEOUT

SHEET NO. 3 OF 8

CREW SIZE — RATING	4 - 70	4 - 70	4 - 70	2 - 65	2 - 65	2 - 70	TOTALS
TIME INTERVAL	10 MINS.	10 MINS.	10 MINS.	10 MINS.	10 MINS.	10 MINS.	60 MINS.
ELEMENTS	TALLIES	TALLIES	TALLIES	TALLIES	TALLIES	TALLIES	TALLIES
PUSH MOLD ONTO CAR	III III	II III	II				16
MOLD NO.	35	34 36	27				
TRANSPORT MOLDS TO SHAKEOUT	I	III		II			6
MOLD NO.	35	34		27			
SHAKEOUT MOLD - HAND	II I						3
MOLD NO.	31 32						
SHAKEOUT MOLD - CRANE	III I	II I	II III	II II	III III	III II	36
MOLD NO.	35	3 34	34 36	36 9	9	9 12	
CASTING TO BOX - JIB	I III I	III		I			12
MOLD NO.	3 35 32	35		36			
CASTING TO BOX - TONGS		III II			II		9
MOLD NO.		3			3		
CASTING TO CAR - CRANE			II	III		III	9
MOLD NO.		I	34	36		9	
REMOVE BOTTOM BOARD		I	I				2
MOLD NO.		35	34				
REMOVE FLASK - HAND	II III						5
MOLD NO.	31 32						
REMOVE FLASK - CRANE		III I	II	III			13
MOLD NO.		35	34	36			
SORT & FILL FLASK				II			2
ASIDE FLASK TO STORAGE	I					II	3
SORT BOTTOM BOARDS	II		I	I			4
REMOVE & SORT CLAMPS, WEDGES, ETC.	III			I	I		6
REMOVE & SORT GAGGERS	I				III	III	8
SHOVEL SPILLED SAND							
CLEAN WORK AREA							
DUMP SNAP MOLDS IN BOX							
UNAVOIDABLE DELAY							
SHAKEOUT	II	III II	III			III	16
CREW		I	III III				10
CRANE		I	III	I		I	8
SUPERVISION				I			1
AVOIDABLE DELAY							
PERSONAL DELAY		I	III II		III		13
				LAST 2 MINS. 3RD MAN IN CREW			
TOTAL TALLIES	40	40	40	22	20	20	182

Fig. 2 — Group timing technique study.

POUR AND SHAKEOUT PRODUCTION REPORT																
SHIFT: 8 a.m. TO: 4 p.m.																
DATE: NOV. 17, 1959																
POURING	8:15 NOV. 17	8:40 NOV. 17	9:08 NOV. 17	9:42 NOV. 17	10:35 NOV. 17	11:01 NOV. 17	11:31 NOV. 17	12:05 NOV. 17	12:20 NOV. 17	1:10 NOV. 17	1:57 NOV. 17	2:30 NOV. 17	2:54 NOV. 17	3:10 NOV. 17	TOTAL	WORK UNIT STD.
100 LB. LADLE															13.0	
400 LB. LADLE		1			1	1				1					4	16.5
100 LB. LADLE		1	1		1	1		1		1		1			7	19.0
TEST BAR		2	1		2	2		2		2		5			16	0.2
DOUBLE POUR																
EXTRA POUR																
MOLDS PER HEAT	122		18		76	62		53		50		19				
HEAT WORK UNITS	180		96		162	154		147		144		99			982	

MOLD VOLUME 1000 CU. IN.	STARTING INVENTORY	ENDING INV.	TOTAL	WORK UNIT STD.		
SQ. SNAP	69		45	40	154	1.0
MACH. SNAP						2.5
0 - 4			57	18	75	2.9
4 - 8	34		8		42	4.7
8 - 13		1			1	6.2
13 - 18	8	18		24	3	47
18 - 23			16		19	12
23 - 28		2	3	9	14	9.2
28 - 33					2	14
33 - 38	1	2			2	1
38 - 43					2	11.5
43 - 48	20		9	2	10	2
48 - 53		4			21	20
53 - 58						4
58 - 63						15.0
63 - 68						
68 - 73						
73 - 78						
78 - 83						

LOST TIME	HRS.	MISCELLANEOUS WORK	NO.	W.U. STD.	SUMMARY	TOTAL
		DESTROYED MOLD - HAND		3.8	POURING	1189
		DESTROYED MOLD - CRANE	3	7.1	SHAKEOUT-MACHINE	1577
		SORT GAGGERS - LOAD	9	38.0	SHAKEOUT-FLOOR	159
		CLEAN ZONE 1	1	47.0	MISC. WORK	436
		CLEAN ZONE 2	1	26.0	TOTAL STD.W.U.	3361
		TRANSFER MOLD TO FLOOR		8.3	DELAY ALLOW. 4%	134
					TOTAL EARNED W.U.	3495

UNMEASURED WORK	HRS.	CREW	TOTAL HRS. WORKED
			48.0
			LOST TIME HRS.
			UNMEASURED HRS.
			LUNCH CREDIT HRS.
			1.8
			MEASURED HRS.
			46.2
			EARNED INDEX
			75.6

Fig. 3 — Timekeeping department record form.

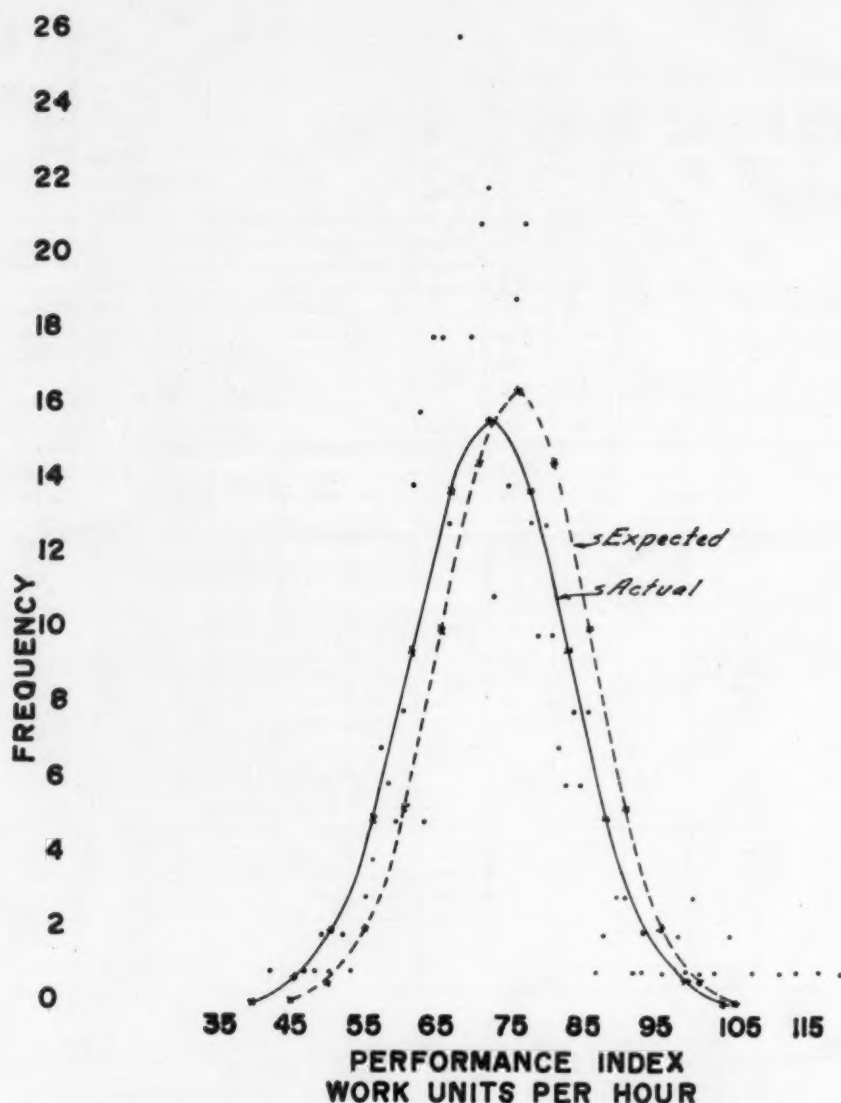


Fig. 4—Standards performance distribution curve for pour and shakeout.

hands of the workers the day after the work is performed.

CONCLUSION

The results obtained from this work measurement program have been favorable. The bottleneck which was a major problem in the foundry operation has been eliminated, consequently eliminating the many lost time hours. The performance level of the pour and shakeout workers has increased approximately 20 per cent.

The workers' earnings have also increased approximately 20 per cent. Administrative cost has been kept to a minimum. Approximately 25 per cent of one man's time per day is required to administer the plan.

Standards have been properly maintained with little difficulty whenever changes occurred which affect the standards.

Through the use of statistical control charts it is possible to reveal significant changes affecting standard time values. The data as developed have made it possible to maintain the control necessary for fair and equitable standards.

In review of the actual frequency distribution of the 1959 performance index, as shown in Fig. 4, the pattern of results obtained are closely similar to the expected pattern as detailed in the labor agreement.

As the difficult problem of measuring indirect non-repetitive operations must be faced more and more, it is felt that today's new statistical tools can aid to open areas for cost reduction efforts that have long been considered too difficult to approach.

REFERENCES

1. H. B. Maynard, *Industrial Engineering Handbook*, first edition, McGraw-Hill Book Co., N. Y. (1956).
2. George Dew, "Group Timing Techniques," Methods Engineering Council Report (1956).

NICKEL CARBONYL PATTERN EQUIPMENT

by J. O. Trimble

ABSTRACT

The nickel carbonyl process for producing pattern equipment is described, from the making of the master mold to the completed nickel pattern. Precautions in working with nickel carbonyl are given. The nickel carbonyl process produces high surface finishes and tolerances, and, according to the author, its capabilities are unlimited within the foundry equipment field.

HISTORY

In 1880, a Welshman named Dr. Mound came upon an interesting phenomenon. He found that if carbon monoxide was passed over heated nickel powders or chips, the carbon monoxide (CO) would burn with a brilliant white light. In analyzing the CO, he found that a new compound had been formed which he called nickel carbonyl $[\text{Ni}(\text{CO})_4]$. It was also found that if this compound in its gaseous state was cooled rapidly, the compound entered its liquid state, resembling ether in appearance and volatility. But, if the compound in its gaseous state was heated above 300 F, the compound nickel carbonyl thermally decomposed forming a nickel powder.

After 20 odd years of research, this process was finally put into use as a production method producing pure nickel from nickel ore. This plant is in Wales, and is still operating on a commercial basis.

In the past 50 years, there have been repeated attempts to utilize the above basic process to produce some end product in nickel via the thermal decomposition of nickel carbonyl. The first commercial end products were produced in 1956. These products were sheet metal forming dies and patterns for the high production foundry.

NICKEL CARBONYL PATTERN MAKING PROCESS

First step in this process is the creation of the master male model. This is accomplished by standard pattern making practice from any convenient material such as, wood, plastic or metal. Figure 1 is a typical plastic model of a four cylinder head pattern. After the pattern has been checked for accuracy, a coating of release agent is sprayed onto it. A mold is then made from this master by spraying a eutectic metallic compound, making a female image of the male master model.

Figure 2 shows the male master model and the

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Fig. 1—Inspecting plastic pattern to blue print.



Fig. 2—Checking sprayed eutectic mold for dimensional accuracy and surface finish.



Fig. 3 — Loading the deposition chamber with eutectic molds.

sprayed eutectic mold which is being checked for dimensions and finish. The female eutectic mold is then placed in the deposition chamber (Fig. 3) along with many other molds, completely filling the chamber area. The chamber is then closed (Fig. 4) and the process is ready to begin. The chamber is purged of all air with carbon dioxide (CO_2) and the molds are heated to 325 F. At this point, nickel carbonyl in its vapor state is introduced into the chamber from the gas generating room (Fig. 5).

When the gaseous nickel carbonyl comes in contact with the mold surfaces which are now 325 F, the

nickel carbonyl thermally decomposes. In doing so, it leaves pure nickel on the surface of the mold releasing carbon monoxide. This carbon monoxide and unused nickel carbonyl is then burned in a fume burner at 2000 F, converting them into carbon dioxide and nickel oxide.

Nickel Carbonyl Toxicity

It should be noted that nickel carbonyl is one of the most toxic known compounds. The allowable limit of nickel carbonyl in its vapor state in the atmosphere is one part per billion. Maximum security and

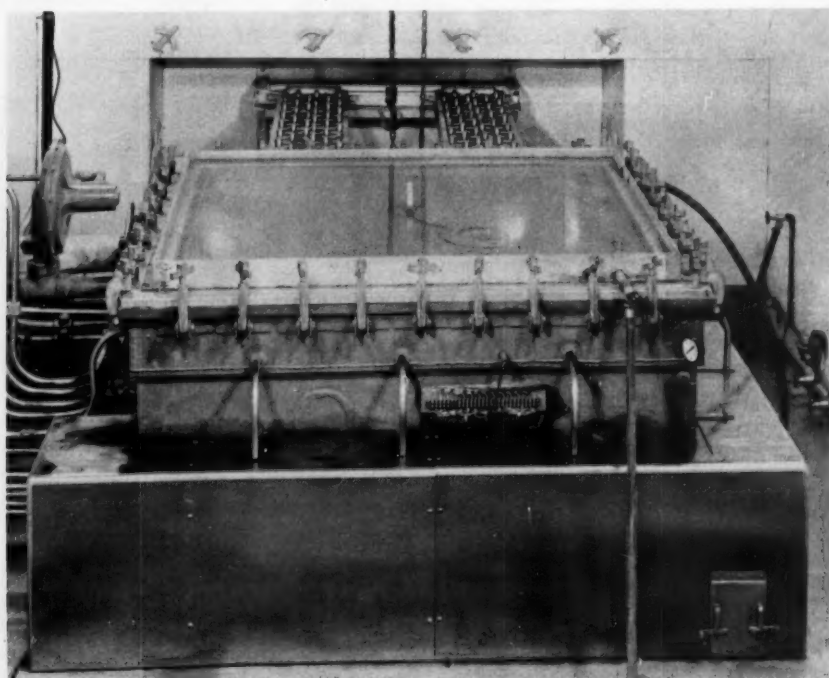
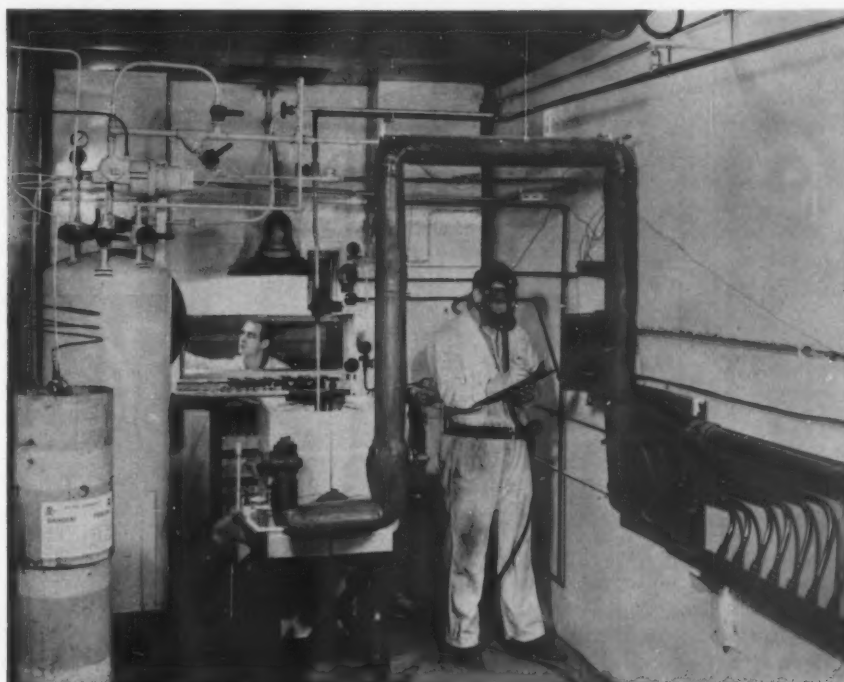


Fig. 4 — The deposition chamber in operation.

Fig. 5 — Introducing vapor nickel into chamber from gas generating room.



procedures must be used in handling nickel carbonyl at all times. The resulting nickel, as produced from the thermal decomposition of nickel carbonyl, is completely safe, and should be handled like cast or wrought nickel or stainless steel.

This decomposition continues to build up nickel in a molecular state on the surface of the mold until the desired thickness is reached. This can be from a few thousandths up to $\frac{1}{2}$ -in. thick of nickel. This is a continuous process and can not be stopped and restarted. When the desired thickness of nickel has

been deposited on the mold face, the process is stopped, the chamber purged with carbon dioxide and then opened and the eutectic molds with a heavy nickel deposit on them are removed, as shown in Fig. 6.

At this point the nickel shell is stripped from the eutectic mold and backed with epoxy resin. A metal based plate is cast into the epoxy to facilitate mounting. The nickel face is then vapor blasted to remove all release agents, and the result is an exact reproduction (Fig. 7) of the original model (Fig. 1). The

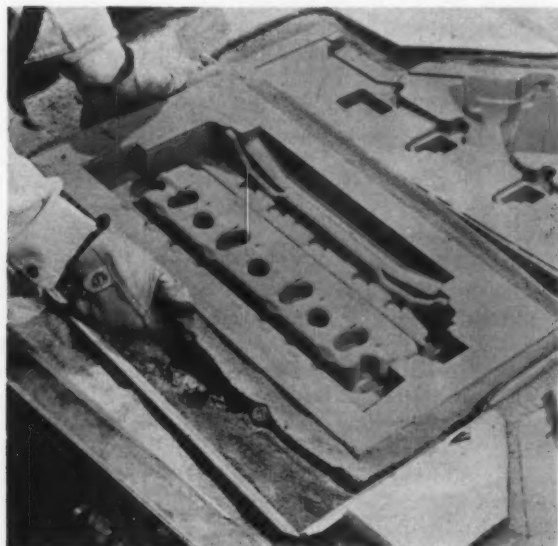


Fig. 6 — Plated eutectic mold being removed from chamber.



Fig. 7 — Finished nickel duplicate pattern.



Fig. 8 — Typical cross-section of equipment made via the nickel carbonyl process.

result is that we have produced from the original model an exact reproduction of that model in nickel without any machining whatsoever. This particular pattern is 20 in. long, and the tolerance between the master model and the nickel pattern is 0.005 in. on any dimension.

Nickel carbonyl patterns made via this process produce nickel with the following physical characteristics:

Tensile Strength, psi	85 to 95,000
Yield Strength (0.2% Offset), psi ..	46 to 56,000
Elongation, %	15 to 22

Hardness, Bhn 181 to 222

The resulting nickel is a tough, highly abrasion resistant metal having a resistance to sand five times greater than cast iron. Nickel carbonyl is slippery by nature, and has excellent release properties from sand binders.

Figure 8 is a typical cross-section of the type of equipment made with the nickel carbonyl process. The nickel carbonyl process has produced green sand patterns, green sand core boxes, shell mold patterns, shell core boxes, permanent molds for aluminum foundries (Fig. 9) and die cast inserts (Fig. 10).

Using the nickel carbonyl process, the all important time interval between design and production can be cut radically as the process generally makes pattern equipment within 50 per cent of the normal time to make machined-all-over metal patterns. The cost of nickel carbonyl patterns is usually somewhat less than the cost of conventional machined patterns. And, as the pieces become more complex, the nickel carbonyl process has a much greater economic advantage. Due to the extremely high abrasion resistance of nickel carbonyl, pattern life is lengthened and maintenance reduced.

The nickel carbonyl pattern can be arc welded, gas welded, brazed, silver soldered or lead tin soldered.

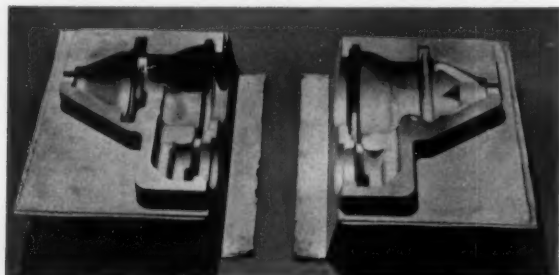


Fig. 9 — Nickel permanent molds for aluminum foundry.

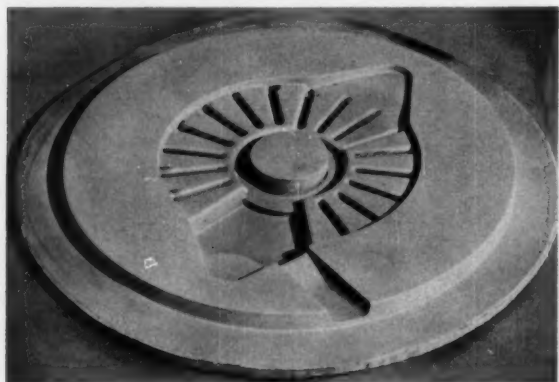


Fig. 10 — Nickel insert for die cast mold.

CONCLUSION

As previously mentioned, this process produces a duplicate of the original model in nickel, and no additional shrink is required on the master model other than that which is necessary for the production of the casting itself. Therefore, using the nickel carbonyl process, it is possible to reproduce from an existing pattern any number of duplicate patterns. The nickel carbonyl process produces extremely high surface finishes and tolerances well within the industry's needs. The capabilities of the process are unlimited within the foundry equipment field, and every day brings new uses for the process within the foundry.

MN-MO ALLOYED PEARLITIC MALLEABLE IRON HARDENABILITY

by R. W. Heine

ABSTRACT

An investigation of the hardenability effects of alloying pearlitic malleable iron with manganese and molybdenum was undertaken. Hardenability test bars 1¼-in. in diameter by 6 in. long were used. Hardenability curves obtained from alloying pearlitic malleable iron with Mn and Mo are given, as are calculated hardenability curves for wrought steel. From the study it is concluded that the potential for successfully hardening and tempering heavy sections exists, and water or oil quench hardening can be used to develop optimum mechanical properties after tempering.

INTRODUCTION

Pearlitic malleable iron is frequently heat treated by hardening and tempering. When this is done, hardenability of the iron becomes important since it prescribes the section thicknesses which can be successfully hardened and tempered. For this reason an investigation of the hardenability effects of alloying pearlitic malleable iron with manganese and molybdenum was carried out as AFS committee work.*

PROCEDURE

Hardenability test castings in the form of bars 1¼-in. diameter by 6 in. long were supplied by three different pearlitic malleable producers. The chemical analyses are listed in the table. The analyses were intended to provide three groups of castings containing 0.20 - 0.25 per cent molybdenum and three levels of manganese percentage; the normal range of about 0.35 to 0.55 per cent, a slightly higher level of 0.65 - 0.90 per cent and a maximum level of about 1.0 to 1.25 per cent. The table shows these objectives were met.

CHEMICAL COMPOSITION

Element	Code No.													
	C-1	C-2	C-3	L-1	L-2	L-3	L-4	N-1a	N-1b	N-2a	N-2b	N-3a	N-3b	
C	2.66	2.67	2.67	2.35	2.35	2.35	2.35	2.50	2.49	2.50	2.49	2.50	2.49	
Si	1.44	1.48	1.45	1.06	1.06	1.06	1.06	1.29	1.25	1.29	1.25	1.29	1.25	
P	—	—	—	0.053	0.053	0.053	0.053	0.05	0.05	0.05	0.05	0.05	0.05	
S	0.142	0.142	0.142	0.132	0.132	0.132	0.132	0.14	0.146	0.14	0.146	0.14	0.146	
Cr	0.018	0.018	0.018	0.01	0.01	0.01	0.01	0.035	0.035	0.035	0.035	0.035	0.035	
Mo	0.25	0.22	0.22	0.21	0.21	0.20	0.22	0.20	0.24	0.21	0.28	0.18	0.18	
Mn	1.33	0.88	0.50	0.40	0.40	0.86	1.25	0.49	0.36	0.85	0.66	1.27	1.08	

Figure* 4 3 2 1 2 3 4 2 3 3 4 4
*Hardenability curves for these alloys austenitized 30 min at 1500 and/or 1600 F fall between the limits shown on the respective figure numbers indicated.

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These analyses were selected since the alloying elements used to increase hardenability (Mo and Mn) can be absorbed into the remelt with little or no subsequent harm to heat treating cycles for pearlitic malleables. The test castings were supplied with a pearlitic malleable structure normally provided by the producer.

After machining to size, the castings were austenitized for 30 min at 1500 or 1600 F, and then quenched by the standard end-quench procedure. Hardness measurements at various distances from the quenched end were made according to the standard procedure. Graphs of Rc hardness versus distance from the quenched end were prepared for a number of individual bars from each lot of castings. The results are summarized in Figs. 2, 3 and 4. The range of hardenability curves expected from unalloyed pearlitic malleable iron is shown in Fig. 1, which is reproduced from a reference.†

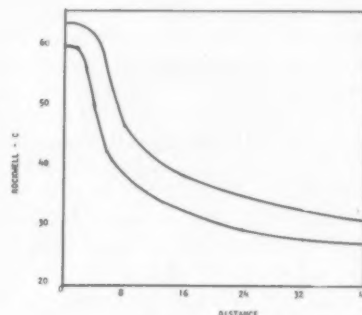


Fig. 1 — Hardenability band for unalloyed pearlitic malleable iron austenitized at 1500 to 1600 F.†

This may be compared with hardenability curves for the alloyed irons of the table, Figs. 2-4. An increase in hardenability is noted with each increase in the percentage of alloying element. The lowest level

*Formerly AFS Committee 6-E, Pearlitic Malleable Committee, whose members are listed below and now under Committee 6-D, Heat treating Committee, Malleable Div. A. H. Karpicke, vice-chairman, W. M. Albrecht, J. E. Kruse, J. H. Lansing, M. Tilley, W. C. Truckenmiller, P. F. Ulmer and E. N. Wheeler (deceased).

†R. W. Heine, "Hardenability of Pearlitic Malleable Iron," AFS TRANSACTIONS, vol. 20 (1958).

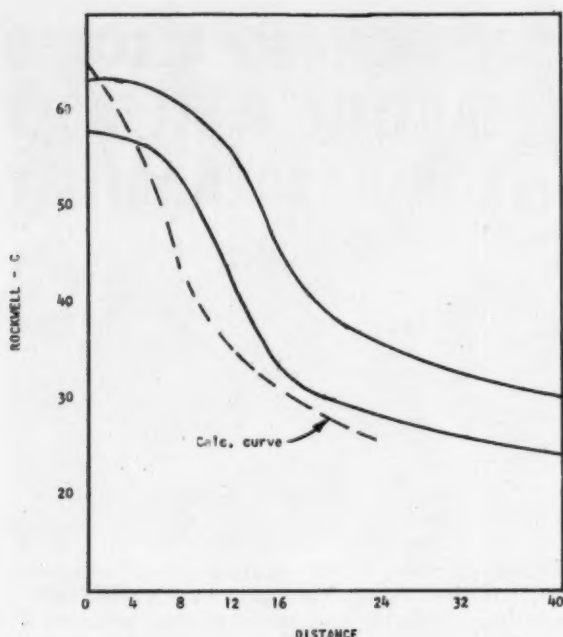


Fig. 2—Hardenability band for pearlitic malleable iron alloyed with 0.20-0.22 per cent Mo and austenitized at 1500 to 1600 F.

of alloying, 0.20 to 0.22 per cent Mo and 0.36 to 0.50 per cent Mn, produced hardenability curves in the band shown on Fig. 2. The intermediate level of alloying, 0.21 to 0.24 Mo and 0.66 to 0.86 per cent Mn, produced hardenability in the range shown on Fig. 3.

The highest alloying percentages 0.18 to 0.25 per cent Mo and 1.08 to 1.33 per cent Mn, develop hardenability curves within the band limits shown on Fig. 4. Within the hardenability bands on Figs. 2,

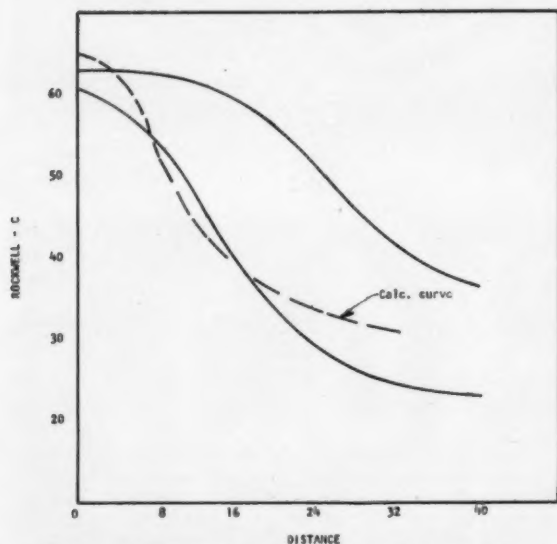


Fig. 3—Hardenability band for pearlitic malleable iron alloyed with 0.21-0.24 per cent Mo and 0.66-0.88 per cent Mn and austenitized at 1500 to 1600 F.

3 and 4, the more highly alloyed compositions in the table and the higher austenitizing temperature of 1600 F produced higher hardenability curves.

Wrought Steel Hardenability Curves

Hardenability curves for wrought steels may be calculated from the chemical analyses with reasonable accuracy within limitations.[†] Calculated hardenability curves are shown in Figs. 2, 3 and 4 for the C group of compositions in the table. The calculation requires a knowledge of the percentage of carbon dissolved in austenite at the heat treating temperature. This was assumed to be 0.60 per cent for these calculations. The calculated curves are seen to predict lower hardenability than that actually obtained, except at the highest level of alloying Figs. 2-4.

This may be due to error in the assumed percentage of carbon dissolved in the austenite. Nevertheless, it is seen that reasonable agreement of calculated and experimentally measured hardenability exists especially with the dissolved carbon percentage assumption. Thus, it appears that these alloying elements improve hardenability in pearlitic malleable to a degree quite comparable with their effect on wrought steels.

SUMMARY

Pearlitic malleable iron alloyed with 0.18 to 0.25 per cent molybdenum and 0.36 to 1.33 per cent manganese provides a wide range of hardenability. The potential for successfully hardening and tempering heavy casting sections therefore exists. Water or oil quench hardening can thus be used to advantage by producers and users of the castings to develop optimum mechanical properties after tempering.

[†]W. Crafts and J. L. Lamont, *Hardenability and Steel Selection*, Pitman Publishing Co., New York.

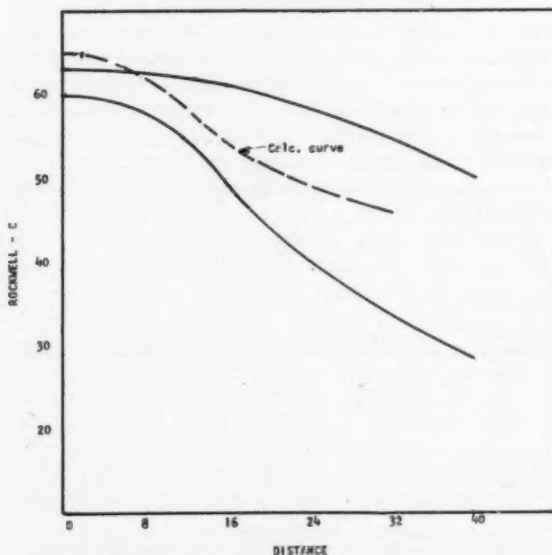


Fig. 4—Hardenability band for pearlitic malleable iron alloyed with 0.18-0.28 per cent Mo and 1.08-1.33 per cent Mn and austenitized at 1500 to 1600 F.

MANAGEMENT BY OBJECTIVE

by Richard W. Wilson

ABSTRACT

Representative operating objectives, together with the control and evaluation procedures used to implement progress in the specific areas, are reviewed by the author. Controls, such as variance reports, budgets and the man-hr/ton index, are yardsticks used to measure this progress. The four areas of objectives covered are—organizational, safety, quality improvement and cost reduction. The overall program of the author's company in these areas is given.

INTRODUCTION

It is generally accepted that the effective management of any enterprise requires planning with well thought out objectives. Without goals there is likely to be haphazard activities with resultant poor utilization of facilities and personnel. The steel foundry industry is accustomed to objectives, especially in the areas of technology where progress is measured in terms of the quality of steel castings produced. The production schedule is another objective well known in the steel foundry industry. In short, the establishment of goals is essential, and certainly not a new concept to the steel foundry man.

It is not sufficient to merely define objectives and strive toward the goals. Channels for information must be developed so that progress can be evaluated according to a yardstick of measurement. Intelligent evaluation of progress toward objectives is essential though often difficult, especially when intangible objectives are involved.

The management of the author's company's foundry division has found that plans can best be communicated to all levels of operating management in terms of specific objectives. Controls, such as variance reports, budgets and the man-hr/ton index, are examples of yardsticks being used to measure progress. This paper will review some representative operating objectives, together with the control and evaluation procedures being used to implement progress in the specific areas.

ORGANIZATIONAL OBJECTIVE

The purpose of defining an organization is to provide correct lines of authority as well as logical communications. This is an intangible objective with the

degree of success or failure measured by progress on such major tangible objectives as cost reduction and even product quality.

Front Line Responsibility

Perhaps the easiest and certainly the most conventional way of describing an organization is to draw a line and staff chart. Unfortunately an organizational chart seems to de-emphasize the status of the member of management who carries the front line responsibility for each of the operating objectives—the foreman. This point is fundamental; the full responsibility for the operation of a department, together with the production of a quality product, is on the shoulders of line management. Staff services such as industrial engineering, inspection and production control are certainly no less important and are essential to continued successful operation, but never take the onus of responsibility from line management.

Channels of Communications

In order to develop lines of communication, a distinction was made between authoritative and informative communications. Authoritative directives pass along the lines of authority. At the production level, all orders related to the direction of activities, discipline and policy must pass from superintendent to foreman and foreman to worker. By the same token, labor grievances and other matters requiring a decision must pass up the line of authority. When requests for decisions are handled in this manner, the decisions are made at the lowest level at which the required information is available.

The treatment of all communications as authoritative would not be sensible in that it would impose unnecessary restrictions and discourage the offering of constructive suggestions. Staff personnel have the right to communicate with all levels of organization, both with regard to offering recommendations and collecting information. When an employee, regardless of status, has a suggestion that he considers to be constructive, he is encouraged to give this idea to anyone he chooses. There is no logical reason for restricting "idea" information to lines of authority, but action on an idea must be considered authoritative.

Information that is developed by staff personnel requiring authoritative action by line management is discussed in meetings attended by those concerned. In

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some cases a committee is appointed to investigate certain recommendations, but the decision to act on a proposal is not a committee function. Decisions on controversial proposals are made by the member of management to whom both parties are responsible.

SAFETY OBJECTIVE

The object here is to provide a safe place to work. On the surface it would seem that progress in this area can easily be measured in terms of statistics, such as accident frequency. In a sense this is true, but it must also be realized that a month, a quarter or even a year without an accident is no guarantee that unsafe conditions do not exist. The number of safety suggestions that spur direct action is considered a good measure of progress toward a truly safe shop.

Safety Committee

The Safety Committee is made up of representatives from each operating department. Initial training sessions were held during which the importance of recognizing unsafe conditions and practices was stressed. The committee members were given authority to correct workers when an unsafe act is observed taking place. Notice that this authority had been vested in the committee was posted on all bulletin boards.

Regular meetings are held and attended by the entire committee, together with members of management. The Safety Director keeps minutes of proceedings, and each suggestion with recommended corrective action is written up in detail. Each suggested action is discussed at succeeding meetings until closed out to the satisfaction of the committee. The person who offers a suggestion concerning an unsafe condition is notified of the action taken to correct it.

When an accident occurs it is investigated by the Safety Director together with two members of the committee. The details of the accident and corrective action, if required, are written up in detail and posted.

The Safety Committee is in effect a channel of communications which can only be kept open and effective by constant use. It is considered extremely important that every safety suggestion offered is investigated and answered. As soon as management ceases to take corrective action on legitimate safety suggestions the entire program collapses.

Safety Contests

The greatest obstacle to a successful safety program is employee apathy, the feeling that accidents happen to the other fellow. Even though the true reward for safe work habits is the saving of an eye and avoidance of painful injuries, it has been found that a \$5.00 prize is inducement to follow safety rules in a contest. Contests have been used to give publicity to safe practice rules, but they are only effective on a short term basis. An additional benefit from a contest is that it provides an indication of the interest that employees have in the general subject of safety.

The only contest of long standing that is currently being used concerns housekeeping. The maintenance of an orderly shop is considered an important factor in developing safe work practices. Each week an hourly paid employee is chosen from each department to serve as the inspector of some other department. The

foreman of the area being inspected accompanies the man and a point system is used for rating. The results of each inspection, together with the name of the inspector, are posted. At the termination of each contest period the department with the highest housekeeping rating is recognized and each of the employees is presented an award.

QUALITY IMPROVEMENT OBJECTIVE

The activities aimed at improving quality of product are actually divided into two separate and distinct categories. Action that is taken to improve the overall quality of product, such as major change in sand formulation, melting practice and the installation or modification of equipment, requires the decision of the Division Manager. This is considered long range quality improvement. The every day objective to improve quality of specific castings and eliminate specific chronic defects is a prime concern of both line foreman and staff personnel. This is the area of quality control that most requires records and followup.

Progress in terms of product quality is indicated in many ways. Scrap reports are definite indications, and cost of salvage is directly related to both the quality standard and status of product quality. Since the author's company is a captive foundry, machine shop variance reports are used as a barometer of casting quality.

Mold and Core Inspection

Casting defects that appear intermittently are without a doubt the most difficult to correct. The source of most intermittent defects is in the mold or cores, a conclusion which prompted the company to appoint a skilled molder to the position of Quality Foreman. His function is to inspect molds and cores, together with the followup function in the machine shop and assembly departments.

The quality foreman is a staff man, and in this capacity he crosses all department lines, but he does not have authority to make decisions that affect production. For instance, if the quality foreman locates a batch of cores that he believes to be questionable, he brings this fact to the attention of the general foreman, as well as the core room foreman. If the general foreman decides that the cores should not be used, they are scrapped and the ticket shown in Fig. 1 is prepared. If, however, the decision is made to use the cores, the ticket is prepared and a followup mark is made either on the cores or in the molds in which they are used.

The castings carrying this identifying mark can be followed in the cleaning room and machine shop. This same procedure is followed when the quality foreman marks a mold that he believes to be a borderline case. Naturally the foreman of the department concerned, the foundry superintendent and the laboratory are all informed of the results of the followup, since it is the quality of these borderline cases that actually determines the standard of quality and hence has a great bearing on overall cost.

Scrap and Salvage Procedure

A scrap ticket, as shown in Fig. 2, is prepared for each casting that is scrapped regardless of cause. A

Fig. 1 — Defective mold and core report snap out form.

record according to cause computed on the basis of per cent of castings produced is maintained daily, and posted weekly on a bar chart that is located prominently in the foundry. In order to spot repetitive cases, a card file is maintained according to both cause of defect and pattern number. When a defect is found to be repetitive for a specific casting, the pattern is "tagged" so that it can be followed the next time that it is run.

If a casting is found to be defective after it enters work-in-process of the manufacturing division, a salvage ticket is prepared which also serves as a move tag transferring the casting to the Salvage Department. The foreman of the Salvage Department either has the necessary salvage work performed or makes out a scrap ticket. The most important part of the scrap and salvage procedure is communications. Copies of each scrap and salvage ticket are sent to each department concerned so that corrective action can be taken.

COST REDUCTION OBJECTIVE

The general area of cost reduction has many corollary objectives. Each time that a material is used or a task is performed, the overall product cost is affected. It is this fact that leads to the need for standards and what is sometimes referred to as "management by exception." A budget is used as a standard for indirect labor and materials, and work standards are being developed on all direct labor operations. The variances from both the budget and work standards are a direct measurement of efforts to reduce costs.

Indirect Labor and Materials Control

A variable budget set up for seven levels of production is used to control indirect labor and supplies in each department. Since costs can only be controlled by

The image shows two forms stacked vertically. The top form is titled "DEFECTIVE MOLD REPORT" (FD-101) and the bottom form is titled "DEFECTIVE CORE REPORT" (FD-102). Both forms have a header section with fields for "PATTERN NO.", "ORDER NO.", "SCRAP", "FOLLOW UP NAME", and "DATE". Below this is a section for "PART NAME", "MOLDING STATION", "MOLD TYPE", and "MOLD WASH". The main body of each form is a large area for "DEFECT & FOLLOW UP" with multiple horizontal lines for text. At the bottom of each form are four checkboxes labeled "FOR RESPECTIVE FOREMAN", "FOR FOUNDRY SUPERINTENDENT", "FOR LABORATORY", and "FOR FOUNDRY OFFICE".

Fig. 2 — Scrap and spoilage report snap out form.

The image shows a single form titled "FOUNDRY - SCRAP AND SPOILAGE" (FD-103). It has a header section with fields for "PATTERN NO.", "ORDER NO.", "SCRAP", "FOLLOW UP NAME", and "DATE". Below this is a section for "PART NAME", "STATION", "CORE TYPE", and "CORE WASH". The main body of the form is a large area for "REASON FOR SCRAP" with multiple horizontal lines for text. At the bottom of the form are four checkboxes labeled "FOR RESPECTIVE FOREMAN", "FOR LABORATORY", "FOR PRODUCTION OFFICE", and "FOR FOUNDRY OFFICE".

those people who are responsible for incurring them, the costs are collected according to "responsibility centers." Prior to each fiscal year the individual foreman is consulted when the budget is prepared for his particular area of responsibility.

Services, such as maintenance of equipment, maintenance of patterns and core boxes and pattern rigging, are all charged to the specific department that benefits from the service. A general foundry account is also used to collect costs that are common to more than one department, and the foundry superintendent held responsible for its control.

The melting, molding and core departments are budgeted on the basis of pounds of good castings poured in a given five week period. The cleaning room uses the same weight levels, but the budget is based on pounds of castings shipped during the same five week period.

A complete breakdown of costs incurred against each account is analyzed when an unexplained variance is reported. When process changes result in savings that are reflected in a negative variance, this is a measure of cost reduction efforts.

Work Measurement Standards

A program of establishing work standards by the standard data method has been in process for several months. Each operation is studied by the industrial engineer and reviewed with the foreman in an effort to simplify before the standard is set. Several benefits of having engineered standards have been experienced, and many more can be foreseen especially in the area of production planning, but the prime overall objective is cost reduction.

The two factors that are considered most important when evaluating the variance report of a unit that is on standards are variance from standard and time lost due to avoidable delays. Since this is a day-work shop, the burden of meeting and exceeding standard is en-

tirely on the shoulders of supervision. The responsibility for minimizing time lost due to avoidable delays is, of course, also the foreman's responsibility. It might seem that the installation of standards increased the burden on front line foremen, but, of course, this is not true. The responsibility of getting maximum production with a minimum of downtime was always present, and the use of standards merely provides a measurement of effectiveness.

When work standards are used in a day-work shop the question arises as to when a worker is to be reprimanded for sub-standard performance. Actually, the company does not consider any definite efficiency value as the boundary line below which sub-standard performance exists. The standard of 100 per cent is set at what is considered normal, and it is expected that production will often go over 100 per cent and sometimes fall below. A plot of efficiency with time should ideally show a scatter pattern with 100 per cent somewhere near the center. If, however, a given operator establishes his normal at some value below 100 per cent, then there is cause for corrective action.

Man Hours Per Ton

The bar graph, shown in Fig. 3, is probably the most popular yardstick of efficiency in the steel foundry industry. The man hours used in computing this measurement is the total of all labor charged to the foundry departments, including corrective labor in the manufacturing division, salvage labor and maintenance. It is the grand total of all labor hours divided by tonnage of good castings produced.

Actually the man-hr/ton graph is a barometer, and is sensitive to almost any change in condition. Product mix, length of production runs, casting quality and efficiency in all departments, are all factors that affect the man-hr/ton figure. It might be said that this is a yardstick that gives an overall measure of

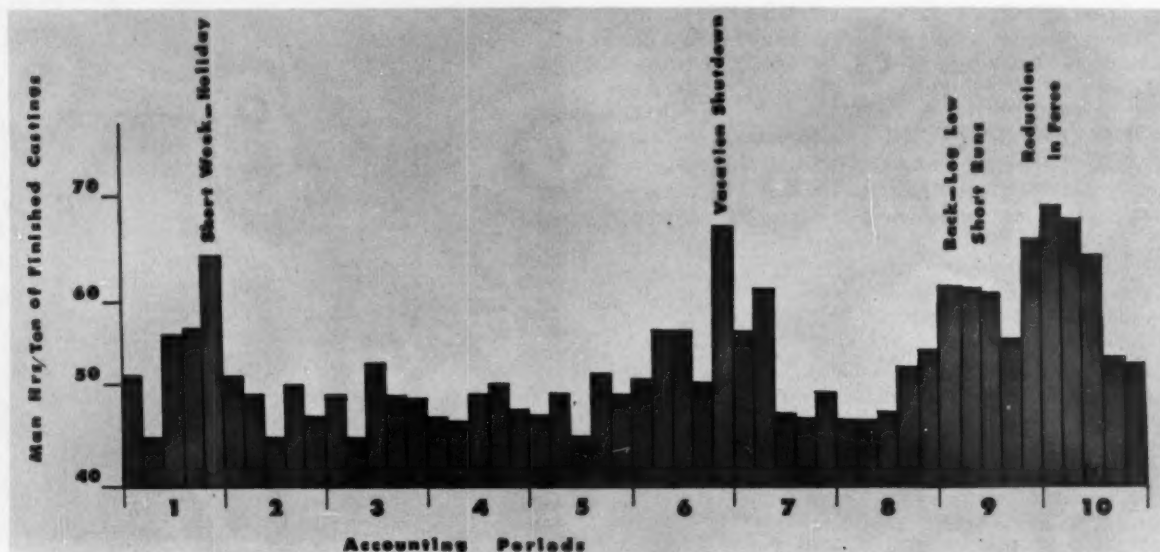


Fig. 3 — Man hours per ton index.

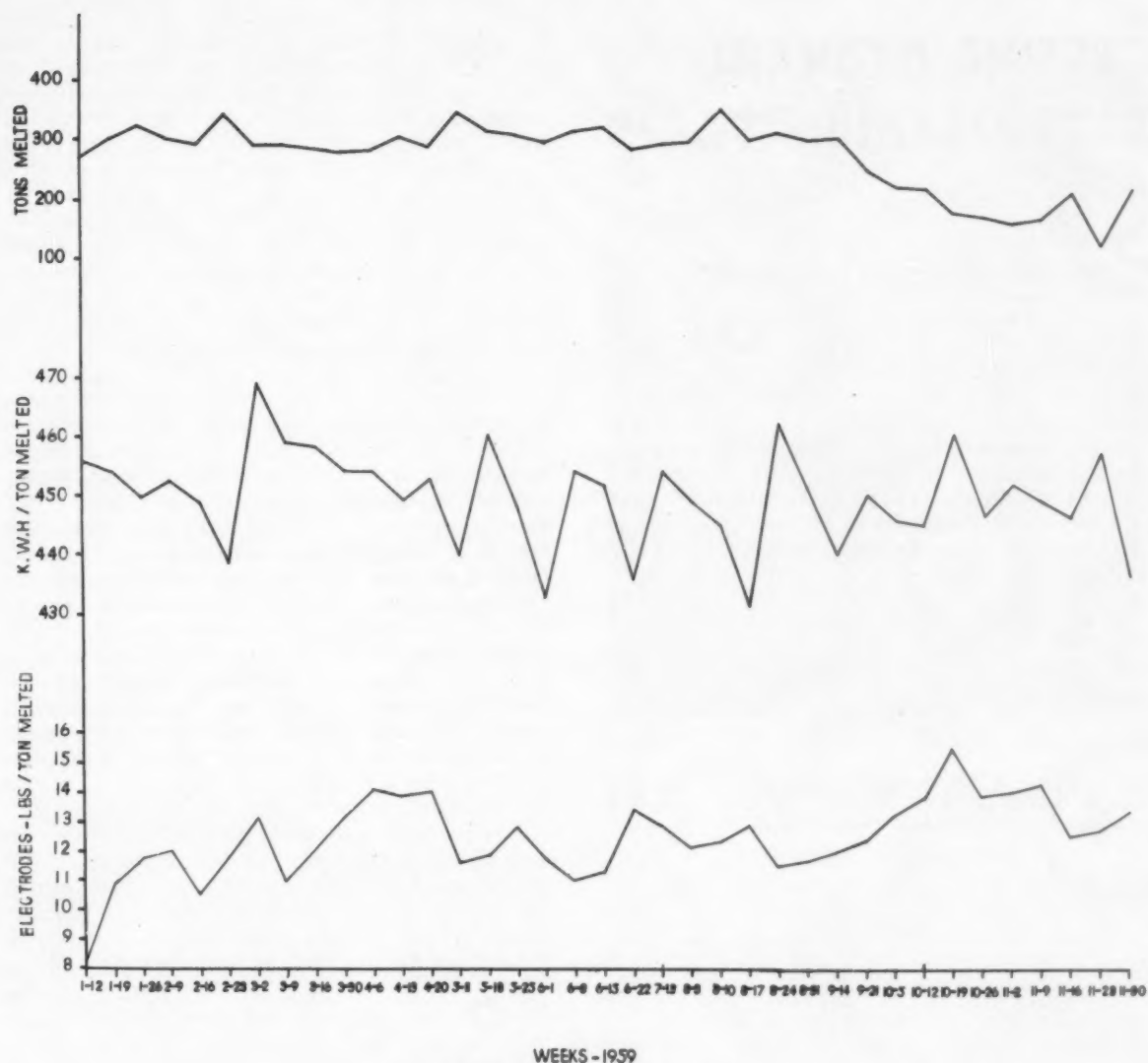


Fig. 4 — Electrode and power utilization.

cumulative efficiency factors. The notations shown on Fig. 3 explain unusual variations from normal. It is interesting to note that in times of decreasing levels of production the man-hr/ton figure increases rapidly, whereas in times of increasing production, the value tends to be unusually low.

Power and Electrode Utilization

The graphs shown in Fig. 4, give an account of electrode consumption and kw hr/ton compared to the levels of production. Again, there are many factors that affect these consumption figures, but they are useful in that variations not considered normal call for an analysis which is the only means of knowing when corrective action is required.

A major cause of high electrode consumption and relatively high kw hr/ton values is low level of operation. Smaller heats result in high electrode consumption, and the necessity of holding a heat to coincide with lower rates of mold production tends to increase both values.

CONCLUSION

When considering objectives it must be realized that the conditions that surround management are constantly changing. As management becomes aware of critical changes it often becomes necessary to re-align objectives. This point was not illustrated by any of the examples discussed. As would be expected, it has been found that the intangible objectives, those concerned with the behavior of people, are especially subject to change, whereas overall major goals remain fixed.

Concentration on specific objectives and the constant evaluation of progress have been found to be an effective pattern for the operating management of the author's company's foundry division. The process of developing information necessary for intelligent evaluation, and, when necessary, corrective action, is essential to the success of the management effort. Above all, channels of communication must be kept open and unrestricted.

CASTING ORDNANCE TYPE TITANIUM PARTS

by H. McCurdy, H. Antes and R. E. Edelman

ABSTRACT

A consumable electrode, arc-type, vacuum furnace has been constructed capable of pouring 110 lb of molten uncontaminated titanium. Two types of mold materials, machined graphite and a rammed expendable graphitic mix, have been used successfully. The mechanical properties of a cast unheat treated 6 per cent aluminum-4 per cent vanadium-balance titanium alloy closely approach those of the same alloy in the wrought, annealed condition.

INTRODUCTION

In 1957, the Ordnance Tank-Automotive Command, Detroit Arsenal, requested Frankford Arsenal

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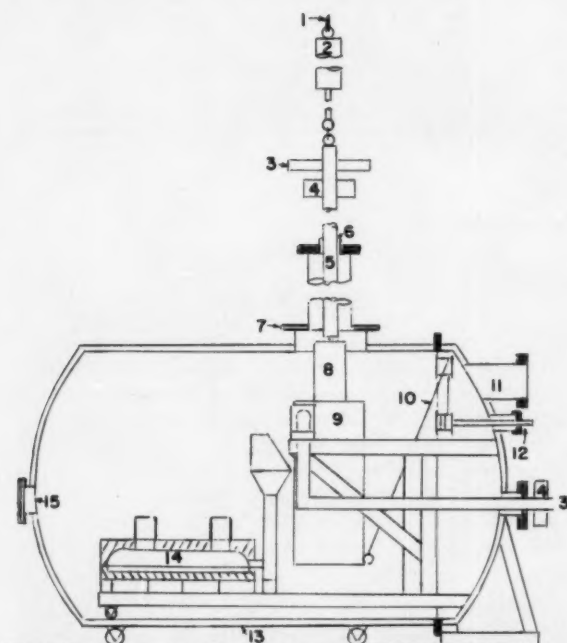


Fig. 1—Skull furnace at the authors' company. (1) Steel cable to electric hoist. (2) Pneumatic cylinder. (3) Water connection. (4) Power connection. (5) Water-cooled stinger rod. (6) Sliding vacuum seal. (7) Electric insulator. (8) Consumable electrode. (9) Water-cooled copper crucible. (10) Tilting mechanism. (11) Vacuum port. (12) Rotary vacuum seal. (13) Water-cooled furnace tank. (14) Graphite mold. (15) Sight port.

to provide titanium castings for an experimental vehicle being built at Detroit. These castings ranged in weight from 5 to 100 lb. Since the larger castings required quantities of molten metal beyond the existing capacity at Frankford Arsenal, a new furnace had to be designed and constructed. The tilting crucible, consumable electrode, vacuum type furnace developed at the Bureau of Mines¹ fulfilled most of the requirements necessary for this work.

Some large plates and ingots had been cast in a similar type furnace at the Naval Research Laboratory.² It was demonstrated, then, that large amounts of titanium could be melted and cast into simple shapes. Therefore, this type of furnace with some modifications and innovations was used in casting the Ordnance parts reported in this investigation.

The complexity of these parts indicated that an expendable type rammed mold would be best suited for the job. Much of the development work carried out on this material has been reported in previous papers. There has been little reported, however, on the use of this material in large, complex molds. The ability to reduce to practice the use of this material was thus an important factor in this investigation.

Foundry problems such as gating, risering and alloying of titanium castings have been discussed by many investigators.^{3,4,5,6,7} These problems, similar to the mold problem, have not been covered with respect to large, intricate castings. The purpose of this investigation, therefore, was not only to produce certain Ordnance parts, but to develop techniques which would be applicable to any future titanium castings.

FURNACE DESIGN

The important features of the furnace are illustrated in Fig. 1. The furnace tank (13) is a double wall construction with water circulating between the walls. The furnace tank is cylindrical with a dome-shaped end. The furnace is closed by rolling along tracks until it meets a fixed dome-shaped cap. The vacuum seal between the furnace and cap is made by means of an "O" ring gasket. The overall dimensions of the furnace tank are 4 ft 6 in. diameter by 6 ft long.

The internal part of the water-cooled copper crucible (9) was made by pressing an 8 in. diameter seamless copper pipe over a lubricated steel mandrel. The 8 to 10 in. diameter taper over 24 in. of the inner part of the crucible facilitated skull removal

after a melt. The outer, or water jacket, part of the crucible was made by rolling a 1/4-in. thick copper sheet into a cylinder and butt welding the joint. The inner part of the crucible was flared to a 13 1/2-in. diameter so that it could be welded to the water jacket in the vertical plane (Fig. 2).

This type of joint eliminated the possibility of contact between the molten titanium and the copper weld during pouring. Extra heavy 2 in. copper pipe attached near the top of the crucible serves as a trunnion for tilting the crucible and as water and power connections. A cable system (10) driven by an electric motor outside the furnace tank is used to tilt the crucible for pouring. The crucible area of the furnace is shown in Fig. 2. The overall dimensions of the crucible are 13 1/2-in. diameter by 26 1/2-in. high.

The electrode assembly consists of an electric hoist (1), pneumatic cylinder (2), stinger rod (5) and consumable electrode (8). The electric hoist raises and lowers the electrode during melting. The pneumatic cylinder provides rapid elevation of the electrode to permit tilting the crucible for pouring. Power is brought into the 6 in. diameter consumable titanium electrode by a water-cooled copper stinger rod. The stinger rod enters the furnace through a sliding vacuum seal (6). The electrode tower and stinger rod are electrically insulated from the furnace tank by a micarta ring (7).

Double Vacuum Arc Melting

It has been found that double vacuum arc melting titanium alloys are homogeneous and have low hydrogen content. Therefore, double arc melted material was used for casting. The consumable electrode for the final melt is made by tack welding together 6 in. diameter vacuum melted ingots. A heli-arc process is used for the welding. A threaded stinger rod adapter is also welded on the assembly to form an electrode approximately 45 in. long. A finished electrode is shown in Fig. 3.

The furnace is evacuated by a 130 cfm mechanical vacuum pump. The vacuum is measured by a thermocouple type gage, an Alphatron and a McLeod gage at three points in the furnace.

The furnace was designed to operate at a maximum amperage of 10,000 dc at 32 volts. The four selenium rectifiers are connected in parallel to provide a maximum of 10,000 amps dc. Normally, straight polarity (electrode-negative) is used during melting.

The arc can be viewed through sight ports (15).

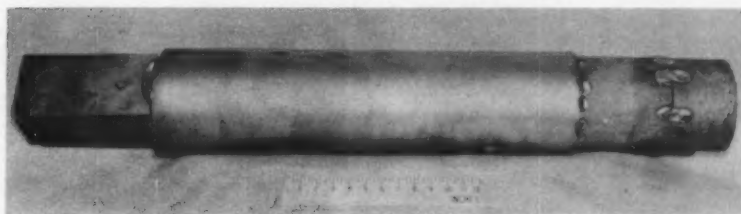


Fig. 3 — Titanium consumable electrode.



Fig. 2 — Water-cooled copper crucible.

The furnace is operated from a control station protected by armor plate for safety.

FURNACE OPERATION

A typical melting procedure may be described as follows. An electrode 6 in. in diameter and up to 48 in. long is attached to the stinger rod and placed in the electrode tower. A titanium skull, a cross-section of which is shown in Fig. 4, from a previous heat is then placed in the water-cooled copper crucible and some clean scrap titanium or titanium



Fig. 4 — Titanium skull.

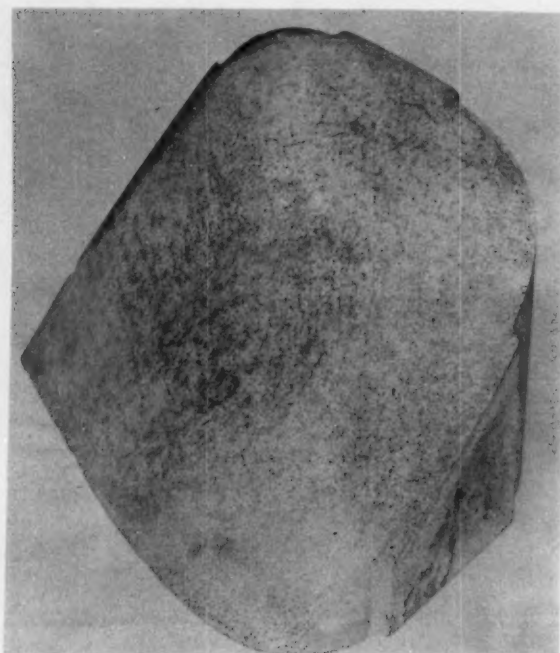


Fig. 5 — Telescope door.

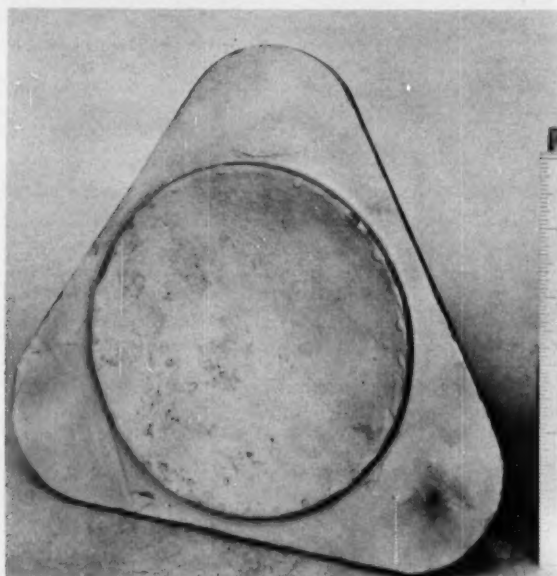


Fig. 6 — Oil fill cover.

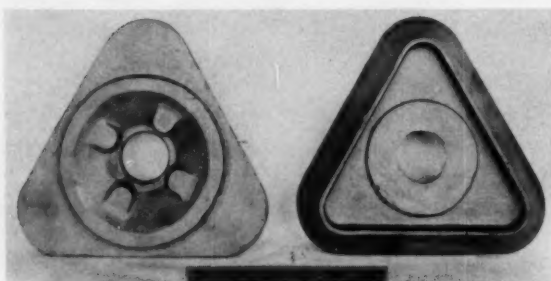


Fig. 7 — Cope and drag of drain hole cover.

sponge is added to facilitate striking the arc. The mold, preheated to 400 F to remove moisture, is next clamped in place.

The furnace is closed and evacuated to 10 microns with a leak rate less than 2 microns/min. The arc is struck at 5000 amps and 30 to 32 volts. The current is then increased to 10,000 amps for operation. As the electrode burns off, the electrode assembly is lowered to maintain the voltage at 30 to 32. The amount of electrode burn-off can be calculated by data from a watt-hour meter. The average burn-off rate is 2.7 lb/kw-hr.

When the crucible contains enough metal to fill the mold cavity and gating system, the arc is extinguished, the electrode is raised by activating the air cylinder and the crucible is tilted. Four to six sec elapse from the time the arc is extinguished until all the metal is poured into the mold. The average ratio of titanium poured to the total amount of molten and solid titanium in the crucible at the time of pouring is approximately $\frac{3}{4}$.

MOLDING PRACTICE

The expendable mold material was selected as the most satisfactory and economical material for making the molds for this program. This material is particularly adaptable where complex shapes and intricate coring are necessary. The molds may be fabricated using common foundry techniques. Production of the mold using this material is more economical than machining from high density graphite. The castings shown in Figs. 5, 6, 7 and 8 were made in the "F.A. graphitic mold material" of the composition shown in Table 1.

It can be seen from this table the mix used in this investigation was similar to the 8 per cent starch mix from reference 7. It should be emphasized that if the starch content is kept down to the lower limit (6 per cent), the degree of inertness of the resulting molds is comparable to machined graphite molds. However, for the molds used in this investigation greater green strength was needed to facilitate pattern removal; therefore, the higher starch content mix was used.

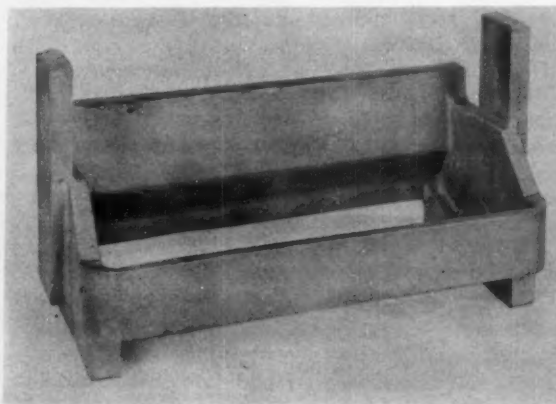


Fig. 8 — Vision block rotor carrier.

TABLE 1—F.A. GRAPHITIC MOLD MATERIAL COMPOSITIONS

Constituent	Parts by Weight		
	This Investigation	Comp. from Ref. 7	Optimum Comp. for 8% Starch
Electric furnace graphite powder (AFS No. 80)	63.0	61.0	63.4
Pulverized Pitch	11.9	11.5	11.9
Carbonaceous Cement	9.5	9.0	9.4
Starch	8.0	(6 to 8% of total)	8.0
Water	6.4	6.0	6.2
Surface Activating Agent	1.2	1.0	1.1

The mixing and molding procedures for rammed graphite follow standard foundry procedures. The graphite powder is blended dry with the starch and pitch in a muller. The water, surface activating agent and carbonaceous cement are mixed in a separate container and then added slowly to the dry mixture while the muller is in operation. After suitable mixing the damp mass is removed from the muller and hand rammed around a wood pattern previously sprayed with silicone mold release.

The mold and pattern assembly are then pressed with a molding machine at a pressure of 100 psi. The mold is stripped from the pattern and flask, vent holes are added and the mold is allowed to dry at room temperature for one to seven days depending on the mass of the mold.

After air drying, the molds are baked to remove residual water and to set the pitch. In this process, they are heated slowly to 250 F (starting at 150 F and increasing the temperature 20 F/hr) and held at 250 F for 16 hr. The molds are then packed in graphite powder and fired at 1800 F for 8 hr. After firing, gates and risers are cut, cores put in place and the molds are assembled for casting.

A shrinkage allowance of $\frac{1}{16}$ -in./ft, from pattern to titanium casting, is used. A typical rammed graphite mold and core are shown in Fig. 9. An assembly view, including machined graphite pouring basin, sprue, gates and risers, is shown in Fig. 10.

SURFACE CONTAMINATION

The extent of the surface contamination of the castings made in the rammed graphite molds was determined by Knoop microhardness traversals. A vision block rotor carrier casting was sectioned to provide specimens for this test. Specimens cut from the casting were used as representative of material cast in machined graphite. The data obtained from micro hardness traverses on these specimens are shown in Table 2. These data are represented by the curves shown in Fig. 11.

It can be seen from these curves that the material cast in the rammed mold had higher surface hardness than the material cast in machined graphite. This small difference in surface hardness is due to the high starch content (8 per cent) that was used.

Fig. 9 — Rammed graphite mold components for vision block rotor carrier.

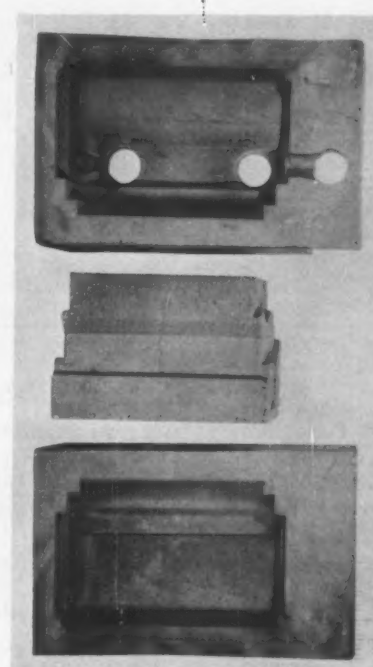


TABLE 2—MICRO-HARDNESS DATA*

Distance From Interface (in.)	Knoop Hardness (500 gm load)	
	Metal From Rammed Mold	Metal From Machined Graphite
0.002	450	385
0.004	380	405
0.006	448	394
0.008	405	393
0.010	440	359
0.014	382	378
0.018	363	396
0.022	361	368
0.026	382	375
0.030	343	375
0.034	349	379
0.038	335	342
0.250	330	369

*Cast Titanium—6 Per Cent Aluminum—4 Per Cent Vanadium Alloy

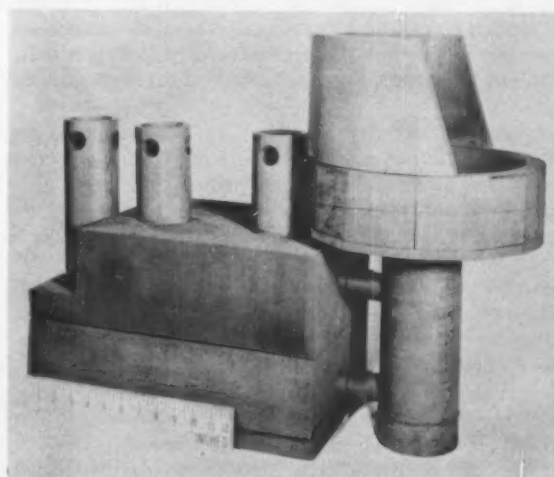


Fig. 10 — Assembled rammed graphite mold for vision block rotor.

TABLE 3—MECHANICAL PROPERTIES*

Melting Condition	UTS, (psi)	YS (psi) 0.2% offset	Elong. (1.4 in. gage), %	R.A. %	Charpy, Im. pact, -76 C	Bhn, 3000 kg Load
Vacuum Melted Consumable Electrode	133,700	117,200	12.0	23.2	13	311
Argon-Helium Melted Tungsten Electrode	134,100	117,100	10.6	20.2	13	302
Argon-Helium Melted Tungsten Electrode	133,700	119,800	6.4	21.0	—	301

*Cast Titanium—6 Per Cent Aluminum—4 Per Cent Vanadium Alloys

CAST MECHANICAL PROPERTIES

Tensile and impact tests were made on specimens cut from a vision block rotor carrier casting. The results of these tests are shown in Table 3. In addition, tensile data are listed in Table 3 from reference 8. The data from reference 8 are for an alloy melted in an argon-helium atmosphere with a tungsten tip electrode.

The chemical analyses for both type melts are shown in Table 4.

TABLE 4—CHEMICAL COMPOSITION OF ALLOYS

	Element (w/o)				Element (ppm)	
	C	Fe	Al	V	H	O
Vacuum Melted	0.1	0.12	6.25	4.05	23	811
Consumable Electrode	0.1	0.16	6.28	4.12	27	836
Argon-Helium Melted Tungsten Electrode	0.1	—	6.04	3.87	—	—

GATING, RISERING AND SHRINKAGE

The high thermal conductivity of the material that is used for the sprues, gates, mold and risers for casting titanium causes rapid solidification of the molten metal. Frequently, it is difficult to obtain the desired directional solidification and feeding that is necessary to produce a sound casting. The use of higher conductivity material for chills may help in some cases, but in general the effect is small. Therefore, shrinkage porosity in titanium castings is common.

Risers placed over areas where shrinkage occurs will eliminate the porosity. Risers must be positioned accurately since the feeding distance of titanium in graphite molds is short.

Recently, gating and risering studies have been made for titanium casting in machined graphite and rammed type molds.⁶

It has been found that normal gating systems that minimize turbulence are applicable to casting titanium. That is, bottom gating and side gating usually are preferable to top gating. Gating ratios of 1:2:2 have been found to be adequate. In addition, it has been found that the minimum riser diameter should be two times the casting thickness for machined graphite molds, and $2\frac{1}{2}$ times the casting thickness for rammed type molds.

The lower thermal conductivity of the rammed molds increases solidification times slightly. Therefore, somewhat larger risers are needed for the rammed mold since the feeding distance will be greater.

The castings made in this investigation and their gating and risering systems are discussed below.

Telescope Door

The telescope door is shown in Fig. 5. The wedge type geometry of this particular casting makes it easy to obtain directional solidification. In this case, a top gate was used that acted as the riser. The general arrangement is shown in Fig. 12. It can be seen from Fig. 12 that a 5 in. diameter riser was used. This riser was 5 in. high. The first casting of this shape was made with a 4 in. diameter riser; however, shrinkage was observed immediately under the riser. Increasing the riser diameter to 5 in. eliminated this porosity and provided sound castings. Total weight of this casting plus riser was approximately 30 lb.

Oil Fill Cover and Drain Hole Cover

The similarity in geometries of the oil fill cover and the drain hole cover can be seen by comparing Figs. 6 and 7. Therefore, the gating and risering that was used was similar. In the case of the oil fill cover the thinnest part of the casting was at the center, and the section size increases toward edges and the corners of this triangular shape. The $\frac{3}{8}$ -in.

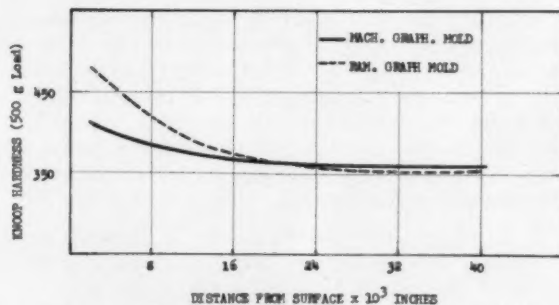


Fig. 11—Knoop hardness vs. distance into metal from mold-metal surface.

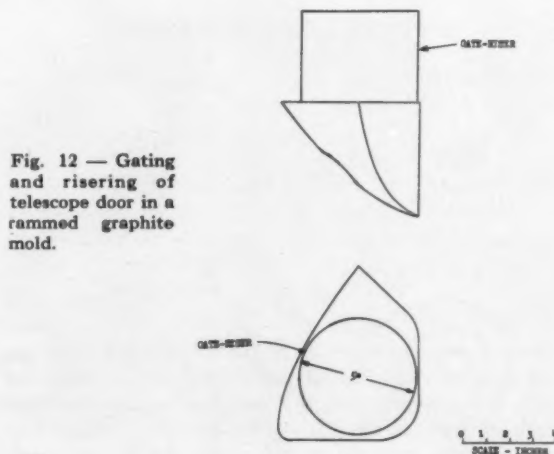


Fig. 12—Gating and risering of telescope door in a rammed graphite mold.

Fig. 13—Gating and risering of oil fill cover in a rammed graphite mold.

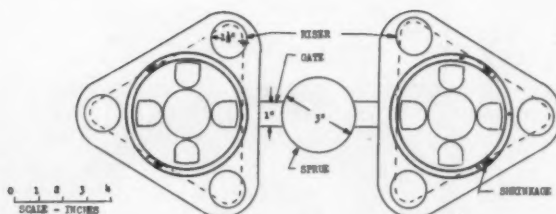


Fig. 15—Gating and risering of vision block rotor carrier in a rammed graphite mold.

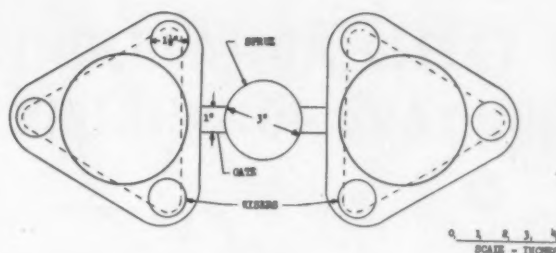
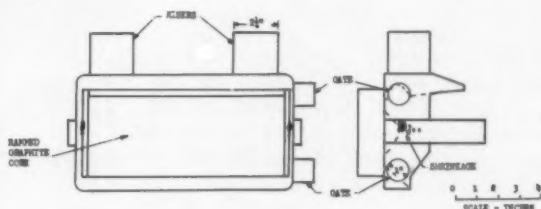


Fig. 14—Gating and risering of drain hole cover in a rammed graphite mold.



section near the corners required approximately $\frac{1}{2}$ -in. diameter riser, according to reference 6. The gating system is shown in Figs. 13 and 14.

In each case two castings were made simultaneously. A pouring basin was used with a 3 in. diameter down sprue. Each casting was side gated with a one in. diameter gate. Radiographs of oil fill cover castings made with the gating system shown in Fig. 13 indicated the castings were sound. However, when the same gating system was used for the drain hole cover casting radiographs revealed porosity in the areas indicated in Fig. 14. The two oil fill cover castings and the two drain hole cover castings with gates and risers each required a pour of approximately 35 lb.

Vision Block Rotor Carrier

A vision block rotor carrier casting is shown in Fig. 8. A 3 in. diameter sprue was used with 2 one in. diameter gates. Two $2\frac{1}{4}$ -in. diameter risers were placed on the heaviest section, as shown in Fig. 15. Radiographs of the castings revealed shrinkage in each of the end sections, as shown in Fig. 15. These defects could be eliminated by padding these sections and using blind risers. This casting, including the gating system, required a pour of approximately 50 lb.

Driver's Hatch Cover

The facilities used for firing the rammed graphitic molds were not large enough to accommodate a mold of the size necessary for the driver's hatch cover casting. Therefore, the mold for this casting was made by machining dense CS grade graphite. In order to determine the amount of molten titanium needed for this casting, a preliminary casting of aluminum was made in the mold. The aluminum

casting was weighed and the weight required to fill the mold with titanium was calculated.

In addition, aluminum castings were made to study general gating and risering techniques. It was found that the finished casting would weigh approximately 100 lb in titanium. The maximum pour from the crucible is about 110 lb. This left only 10 lb of metal available for the gates and risers. A 4 in. diameter top gate was used that also acted as a riser (Fig. 16). This particular arrangement was used because of the amount of molten metal available for pouring. The resulting casting is shown in Fig. 17.

This figure shows the drag surface. The riser was placed at the lower left-hand part of the casting. Shrinkage was observed in the heavy section furthest from the riser. This shrinkage can be eliminated by placing a riser in that area. Currently, a new crucible is being made for the furnace so that larger pours can be made. This will permit the use of more adequate gates and risers in the driver's hatch cover casting.

DISCUSSION

The furnace constructed for this work proved satisfactory for providing 110 lb of uncontaminated molten titanium. However, more molten metal is necessary to produce a sound driver's hatch cover casting. Currently, a larger crucible is being made that will provide at least 150 lb of titanium for pouring.

Vacuum melting removes hydrogen from titanium and low hydrogen content was observed in the castings made in this study. One of the principal difficulties of casting titanium is that the pour must be made as rapidly as possible to maintain the required super heat. Rapid pouring invariably causes splashing and turbulence of the molten metal in the mold cavity. Splashing of metal in conjunction with the

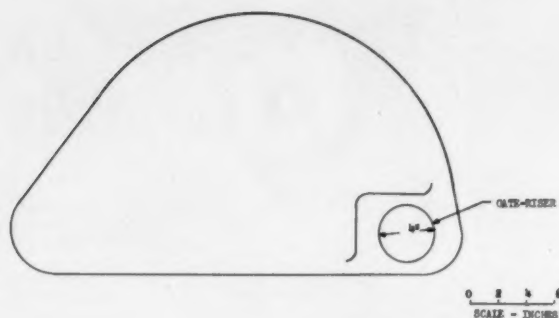


Fig. 17 — Driver's hatch cover.

high thermal conductivity of the graphite mold causes a surface with occasional cold shot.

It has been observed that a surface that is rippled and which contains cold shot is more prevalent in smaller casting, and in those castings made in machined graphite molds. The lower thermal conductivity of the F.A. graphitic mold material eliminates rippled surface and tends to reduce cold shot.

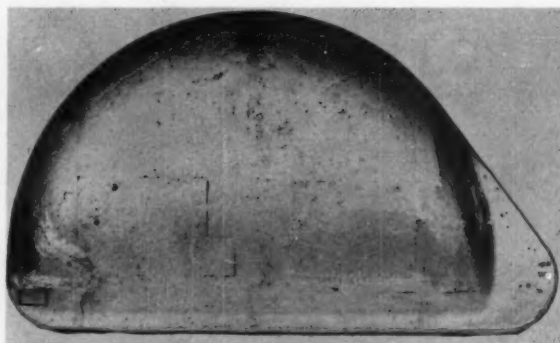
The machined graphite molds that were used in this work were designed so that after casting the mold components could be removed without damage. In the case of the rammed molds the cope, drag and cores were molded as one piece each. As a result, the mold components were usually damaged during "break out" so that the rammed molds could be used for one casting only.

The fact that castings made in the F.A. graphitic mold material had slightly higher surface contamination than is observed when machined graphite (CS grade) is used can be attributed to the use of an 8 per cent starch mix. It has been shown that castings made in a 6 per cent starch mix are comparable to castings made in machined graphite molds.⁷

The tensile strengths of vacuum melted and argon-helium melted titanium—6 per cent aluminum—4 per cent vanadium alloy are approximately the same (Table 3). However, there is a considerable difference in the elongations. The vacuum melted alloy exhibited elongations of 10.6 to 12 per cent, while the elongation of the argon-helium melted alloy was 6.4 per cent. It is interesting to note that the tensile properties of the vacuum cast alloy closely approach the specified properties of the equivalent annealed wrought alloy (i.e., UTS—135,000 psi; YS—120,000 psi; Elong.—11 per cent).

Large sprues, runners and gates are necessary for casting titanium because the relatively high thermal

Fig. 16 — Gating and risering of driver's hatch cover in a machined graphite mold.



conductivity of the graphite used for these components chills the metal rapidly. The rapid solidification of the cast metal accompanied by unfavorable geometry with respect to directional solidification frequently makes the problem of obtaining a sound casting exceedingly difficult. If the geometry is favorable for directional solidification, however [i.e., the telescope door (Fig. 5) and the oil fill cover (Fig. 6)], sound castings are obtained.

ACKNOWLEDGMENT

The authors wish to acknowledge the valuable assistance given them by J. Stephanic and B. Trock of the Ordnance Tank-Automotive Command, Detroit Arsenal.

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INOCULATION EFFECT ON RISERING OF GRAY IRON

Progress Report
Gray Iron Division
Sponsored by
AFS Training and Research Institute
by H. D. Merchant and J. F. Wallace

ABSTRACT

This investigation was conducted to determine the reason for increased shrinkage or risering requirements of gray iron resulting from inoculation of metal poured in green sand molds. Fourteen groups of risered castings were produced in both green and core sand molds with various amounts of inoculants under controlled conditions. The iron employed was cupola melted with a carbon equivalent from about 3.6 to 4.0 per cent. Effective inoculation was obtained with ferrosilicon containing appreciable aluminum and calcium and aluminum metal added with ferrosilicon; however, pure silicon was not an effective inoculant.

Effective inoculation of gray iron produced a considerable amount of mold wall movement in green sand molds in excess of that resulting from the increase in carbon equivalent. This amount of mold cavity enlargement in green sand increased with increased amount of inoculation. Little tendency for increased mold wall movement in core sand molds resulting from inoculation was observed.

It is concluded that the increased shrinkage resulting from the inoculation of gray iron poured in green sand molds was the result of larger amounts of mold wall movement. It is hypothesized that the inoculation produces a more mushy type of solidification and delays the formation of a solid metal skin. This type of solidification together with the increased number of nuclei and finer cell size produced by inoculation combine to produce a weaker casting wall and more confined internal pressure, and tend to produce more mold cavity enlargement.

INTRODUCTION

This is a report of further progress of work on the risering of gray iron castings sponsored at Case Institute of Technology by the AFS Training and Research Institute and performed under the direction of the Research Committee of the Gray Iron Div. A previous report¹ was submitted on the feeding distance of gray iron castings. The portion of the project reported in this paper was directed towards a deter-

mination of the influence of inoculation on risering requirements and reasons for any such influence.

Gray iron and other metals solidify by a process of nucleation of solid particles in the liquid metal and the growth of these into the remaining melt. This nucleation or initiation of solidification is usually preceded by some undercooling of the liquid melt below the theoretical or so-called thermodynamic liquidus or melting temperature. The first solidification which occurs in hypoeutectic iron or in iron with a carbon equivalent below 4.3 per cent is in the form of primary austenite, almost always in a dendritic form.

The solidification of these dendrites proceeds over a range of temperatures, and as the temperature is lowered the remaining liquid is enriched in dissolved carbon. Eventually, the temperature reaches the upper limit of the eutectic temperature range and the remaining liquid attains the eutectic composition. If the iron has a hypereutectic composition (over 4.3 per cent carbon equivalent), primary graphite solidifies first over a temperature range before the eutectic temperature and composition are attained.

The solidification of the eutectic cells of secondary austenite and graphite is controlled by nucleation and growth previously discussed. The melt of eutectic composition may undergo considerable undercooling below the top of eutectic temperature range before the solidification of eutectic cells begins. Such undercooling is capable of producing a great change in the type and form of the graphite constituent. Type A graphite is obtained if the undercooling is slight, and Type D graphite results from appreciable undercooling.² If the undercooling is great, white iron, or the Fe_3C -austenite eutectic, may solidify.²

Gray Iron Inoculation

Inoculation of gray iron is a means of controlling the undercooling of the eutectic, and, therefore, greatly influencing the graphitic structure. By the addition of effective inoculants such as ferrosilicon containing considerable aluminum and calcium, calcium silicon, graphite or special mixtures of alloys, foreign nuclei are introduced from which the solidification of eutectic cells is started.³

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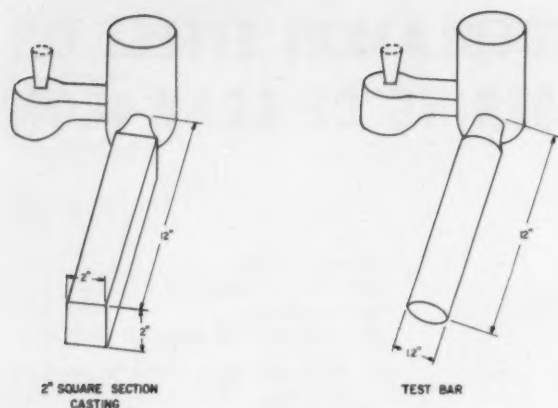


Fig. 1—Gating and risering of castings.

It appears to the authors that these additions, either as added or as compounds which are produced by reactions with other constituents in the melt, may actually serve as nuclei for graphite phase of the eutectic. This graphite is not nucleated by austenite since the graphite-austenite eutectic is anomalous in nature.⁴ Inoculation is most effective and commercially practiced with hypoeutectic irons, because graphite nuclei for eutectic solidification are not provided by the solidification of a primary graphitic phase as in hypereutectic irons.

The introduction of stable effective foreign nuclei for eutectic solidification by inoculation reduces undercooling and favors Type A graphite.² In addition, the presence of a large number of nuclei results in a large number of eutectic cells.⁵ With the solidification of the eutectic starting from a large number of locations and with reduced undercooling, the graphite flakes in the eutectic cells grow slowly into the remaining liquid and do not branch frequently. This produces a thicker, unbranched flake structure characteristic of Type A graphite.

In contrast, however, the uninoculated iron undercools to a considerably greater extent before the start of solidification, and has fewer centers of nuclei from which the solidification of the eutectic proceeds. The result is much more rapid solidification of fewer eutectic cells with thin, branched and elongated graphite flakes and larger cell size. These types of structures in Type A and D graphite have been demonstrated by some researchers.^{6, 7, 8, 9}

Type A Graphite

Type A graphite and the usual small cell size which occurs with this type of graphite are favored by any melting or solidifying factors which favor the presence, or an opportunity to function, of effective nuclei. Increasing the temperature of the melt tends to destroy nuclei existing in the melt at lower temperature and does not favor Type A graphite or small cell size.^{10, 11, 12} Increasing amounts of graphite containing metal in the furnace and cupola charge, however, favors the presence of nuclei and smaller cell size with Type A graphite. Vibration of a solidifying melt produces more effective nuclei and

finer cells with coarser graphite.^{13, 14, 15} It is also obvious that the reduced undercooling produced by the presence of these nuclei drastically reduce mottling or chill depth of the iron.^{2, 5}

Type A graphite generally exhibits improved mechanical properties compared to Type D. These improved properties are believed to be the result of both the matrix and graphite structures. The fewer, shorter flakes of Type A graphite cause less concentration of stress at the edges of the flakes than more frequent, longer, branched flakes of Type D graphite. The increased distance in the matrix between flakes in Type A graphite favors a pearlitic matrix, whereas the shorter distance between the thinner Type D graphite flakes tend to produce a ferritic matrix.

It has been shown that the tensile strength, shear resistance, hardness, compressive strength, modulus of elasticity and wear resistance are superior with Type A graphite compared to Type D.⁶

One undesirable effect of inoculation, or increasing the number of effective nuclei so that eutectic cell size is reduced, is an increase in shrinkage problems. Numerous investigators have observed that inoculated gray iron exhibited more shrinkage than uninoculated gray iron, and therefore required heavier risering to avoid shrinkage defects.^{12, 17, 18} This same phenomenon has been observed by foundrymen both in production and in research.

This investigation was undertaken in an attempt to explain why inoculation, the presence of effective nuclei and fine eutectic cell size, causes more shrinkage. It is hoped that by determining the cause of this shrinkage behavior, methods of reducing the risering requirements of inoculated irons may become apparent or at least the mechanism may be understood so that appropriate risering can be employed when necessary.

PROCEDURE

The castings employed were a 2 x 2 x 12 in. square cross-section bar and 1.2 in. diameter, 12 in. long test bar. Both bars were cast horizontally with one riser located at one end. The castings were gated tangentially into the riser, as shown in Fig. 1. The dimensions of the gating system, riser and riser neck were obtained by calculations,^{19, 20} and designed to produce a casting free from gating defects and shrinkage.

The details of pouring times, riser, riser neck and gating system dimensions are listed in Table 1. Both risers were cylindrical with closed top and hemispherical bottom. The height of the cylindrical section of the riser was equal to the diameter. The square bar casting was selected to provide considerable surface area, and also be sufficiently chunky to avoid mottling in all cases.

A special type of chill block was cast from each iron produced. This block was approximately 1¼-in. thick, 5½-in. wide and 9 in. high with ¼-in. radius notch cast longitudinally in the center of the two largest surfaces. Molten iron was poured directly into the open top of an oil-bonded, baked core sand mold of these internal dimensions. The bottom of

the mold cavity with 5 in. long and 1 1/8-in. wide face rested on a one in. thick steel block to obtain the chill effect.

The two in. square bar castings were poured in both green and oil bonded baked core sand. The 1.2 in. diameter test bars were produced only in the core sand. All molds were made on a squeeze jolt molding machine under equivalent conditions. The molds were compacted in slip flasks and jacketed for pouring. Mold hardness on the green sand molds was maintained approximately constant. The sand utilized for green sand molds was the regular system sand employed in the production foundry.

Standard AFS tests results on this system sand made during this period, and the composition of the sands employed are shown in Table 2. The base sand for the system and for cores was a subangular Michigan lake sand with an AFS Grain fineness number of 50-53 and 3 1/2 screen distribution. Except for the vertically cast chill blocks, all castings were poured in a leveled horizontal position after the addition of weights to the top surface of the cope. At least a two in. layer of sand surrounded all parts of the casting to prevent rapid loss of heat at any location. The castings were allowed to solidify without moving and were cooled overnight in the mold before shakeout.

Melting Practice

The iron was melted in a commercial, hot-blast, acid-lined, 54 in. diameter cupola, transferred to a holding ladle, tapped from the holding ladle into preheated ladles and poured into the molds. The cupola charge consisted of various amounts of pig iron, steel and gray iron scrap with small additions of silicon carbide and ferrosilicon for analysis control. The approximate cupola tapping and pouring temperatures were 2800 and 2650 F, respectively, as determined by optical pyrometer.

The pouring temperatures of the castings varied from 2450 to 2580 F as check by Pt—Pt—10 per cent Rh thermocouple. Care was taken to control tapping, inoculating and pouring temperatures as closely as possible for all heats. Such control of these temperatures is essential because of their observed influence upon the mode of solidification.^{10,21} The temperatures are reported separately for each group of castings in the tables that will be referred to subsequently. In each heat, inoculants with varying quantities of Si, FeSi and Al were added into the metal stream while the metal was being transferred from the holding ladle into pouring ladle.

Then the metal was stirred vigorously with a steel rod for a few seconds and the melt allowed to drop to the desired temperature before pouring. The chemical analysis of the various heats poured will be described in detail in subsequent paragraphs. The carbon equivalent was maintained within 3.6 to 4.0 per cent because these types of irons are the compositions usually inoculated. The variations in silicon content are considerably wider than in carbon.

Utilizing the design of casting, type of sand mold,

TABLE 1—POURING TIMES, RISER AND GATING SYSTEM DIMENSIONS

	Casting Number	
	1	2
Casting size, in.	2 x 2 x 12	1.2 D x 12
Pouring time, sec.	11	3.23
Riser diameter		
x riser height, in.	2 1/2 x 2 1/2	1 1/4 x 1 1/4
Riser neck diameter		
x length, in.	1 x 3/4	3/4 x 1/2
Bottom diameter		
of sprue, in.	1/2	7/16
Top diameter of sprue, in.	3/4	3/8
Sprue height, in.	6	3
Runner section, in.	1 x 1	3/8 x 3/8
Sprue weld diameter		
x height, in.	2 x 2	2 x 2

molten metal and pouring practice described above, two separate experimental series of castings were produced. The first series of castings were intended to demonstrate the influence of composition, particularly carbon equivalent, on casting behavior with various types and amounts of inoculants. The second series of castings were designed to demonstrate only the effect of various amounts and types of inoculants, with composition held as closely as possible.

Inoculation

In the first series of castings, ten groups, each consisting of one 2 in. square bar in both green and core sand and one 1.2 in. diameter bar, were produced. Groups 1 and 2 were not inoculated and had close to the same analysis but were poured with an intended temperature difference of 100 F. The remaining eight groups were cast in pairs with the same pouring temperature and essentially the same composition for each pair.

However, the type of inoculant differed between the two groups in each pair. The first group of each pair was inoculated with commercially pure silicon, and the second one of the pair was inoculated with ferrosilicon containing considerable calcium and aluminum. The same amount of silicon addition was

TABLE 2—COMPOSITION AND PROPERTIES OF GREEN AND CORE SAND

Composition, % by Weight	Properties
Green Facing Sand	
System Heap Sand.....	82.25
Lake Sand	7.20
Added Seacoal	0.56
Added Western	
Bentonite	1.52
Added Hard Wood	
Flour	1.16
Added Pitch	0.06
Added Cereal	0.25
Core Sand	
New Lake Sand	74.92
Reclaimed Sand	11.86
Bank Sand	6.87
Cereal	0.75
Iron Oxide	1.87
Kerosene	0.26
Fast Baking Oil	0.97
Water	1.56
Hard Wood Flour	0.94
Green Compression	
Str., psi.	12.5
Permeability	115
Rammed Hardness	
in Mold	85
Total Moisture, %	4.0
Total Clay, %	5.0
Total Combustibles, % ..	8.5
Green Compressive	
Str., psi.	1.0
Baked Tensile Str., psi, 280	
Baked Scratch Hard-	
ness	95
Baked Permeability	128
Green Moisture, %	2.5
Baking Time, min	80
Baking Temperature, F	425

TABLE 3—CASTING DATA ON FIRST SERIES

Group No.	Pouring Temp., F	Composition, %*			Carbon Equivalent, %	Type of Inoculant	Si in Inoculant, %
		C	Si				
1	2480	3.17	1.35	3.64	none	—	—
2	2580	3.08	1.41	3.57	none	—	—
3	2540	3.10	1.56	3.64	Si	0.15	0.15
4	2540	3.08	1.68	3.66	FeSi	0.15	0.15
5	2525	3.10	1.65	3.67	Si	0.30	0.30
6	2525	3.17	1.61	3.73	FeSi	0.30	0.30
7	2520	3.15	1.68	3.73	Si	0.45	0.45
8	2520	3.19	1.81	3.81	FeSi	0.45	0.45
9	2510	3.13	1.90	3.78	Si	0.60	0.60
10	2510	3.10	2.31	3.89	FeSi	0.60	0.60

*Entire series contained 0.70% Mn, 0.085% S, 0.057% P.

made with both ferrosilicon and pure silicon. The amount of silicon added as either ferrosilicon or pure silicon was increased with successive pairs; groups 3 and 4, 0.15 per cent Si; groups 5 and 6, 0.30 per cent Si; groups 7 and 8, 0.45 per cent Si; and groups 9 and 10, 0.60 per cent Si.

The odd numbered groups were inoculated with pure silicon and even numbers with ferrosilicon. The pouring temperatures, composition, carbon equivalent and amount and type of inoculant are listed in Table 3. The reported composition of pure silicon and ferrosilicon is:

Inoculant	Si	Al	Ca	Fe
Pure Silicon, %	98.95	0.09	0.01	0.54
Ferrosilicon, %	84.60	1.80	0.30	rem.

In the second series of castings four groups were poured, each consisting of one 2 in. square bar in green and in core sand, one test bar and one chill block. The pouring temperature and composition were maintained as constant as possible in all castings of the series. Group 11 was inoculated with pure silicon; Groups 12, 13 and 14 were inoculated with same amounts of ferrosilicon but with increasing contents of 1/4-in. diameter aluminum shot. The composition of the silicon and ferrosilicon is listed in the previous paragraph.

The aluminum was of super purity containing less than 0.001 per cent calcium. Aluminum was employed because it has been shown that this metal is an effective inoculant when added with ferrosilicon.²² It must be pointed out, however, that even fairly small aluminum additions can produce pinholes, particularly in light sectioned castings made in green sand molds. The amount of inoculant added to each group was so adjusted as to obtain irons of the same final silicon content.

The chemical analysis, pouring temperature, carbon equivalent and type and amount of each inoculant for all groups in this second series are listed in Table 4. The pouring temperature decreased approximately 30 F from the first to the last group, but the composition was held within close limits.

Castings Used

After casting and cooling in the mold, the various types of castings were processed to obtain the de-

sired information on structure, dimensions, weight, composition and mechanical properties. The 2 in. square bar castings were sectioned by saw cutting at the center of the riser neck and weights, and volumes of both casting and riser were determined. The weight of each was measured to an accuracy of ± 2 grams on a scale; the volume was determined by immersion. In the first series, the riser plus ingate weight was obtained; only the riser weight was measured in the second series.

The 1.2 in. diameter test bar was employed to determine the chemical composition, microstructure, tensile strength and hardness of each group. Drillings for chemical analysis were removed from the runner of the test bar. The portions of the bar closer to the riser were machined to standard 0.505 in. diameter, 2 in. gage length tensile test bars. The portions of the bar remote from the riser were polished and etched to develop the eutectic cell size and type of graphitic structure for each group. The cell size was developed by deep etching with Stead's reagent; the matrix structure was observed after etching with nital.

TABLE 4—CASTING DATA ON SECOND SERIES

Group No.	Pouring Temp., F	Composition, %*			Carbon Equivalent, %	Inoculant, %		
		C	Si			Si	FeSi	Al
11	2550	3.35	1.86	4.00	0.50	—	—	—
12	2540	3.32	1.88	3.97	—	0.63	—	—
13	2530	3.36	1.90	4.01	—	0.63	0.0063	—
14	2520	3.32	1.94	3.99	—	0.63	0.0126	—

*Entire series contained 0.83% Mn, 0.073% S and 0.059% P.

Because of a nonuniform, finer cell size near the outside surface of the 1.2 in. diameter bar, the cell count was made only on the 1.0 in. diameter section at the center of the bar. The Brinell hardness of each iron was obtained by testing the center of a ground transverse round removed from close to the longitudinal center of each 1.2 in. bar.

RESULTS AND DISCUSSION

Examination of the 2 in. square, 12 in. long bars provided the most significant data in this investigation. All cast bars appeared sound visually without evidence of sinks or draws. The internal soundness of several of these bars cast under various conditions was checked by sectioning and etching, and the bars thus examined were found to be completely sound in every case. The risers showed evidence of feeding the 2 in. square bars in all cases, but the size of the shrinkage void in the top of the riser varied with the metal and mold.

The appearance of a typical set of four risers with gate attached are shown in Fig. 2 after removal from the bar casting, and also after sectioning longitudinally. The sectioned portions provide details of the relative amount of shrinkage void in the riser top and exudation which has occurred in each case. Included in the four are inoculated and uninoculated

Fig. 2—Gates and risers from 2 in. square bars.

irons cast in both green and core sand molds. They were cast in Groups 5 and 6 in the first series of experiments. All four risers shown have essentially the same composition and were poured at approximately the same temperature.

As was generally the case throughout all groups, the green sand castings exhibited considerably greater riser shrinkage voids in the top than those cast in dry sand molds. Inoculation increased shrinkage considerably in green sand castings, but little in those cast in core sand molds. While some exudation was generally observed in all risers, it was more in evidence in the shallower riser shrinkage cavity of castings produced in core sand molds than in the deeper riser shrinkage cavity in green sand castings.

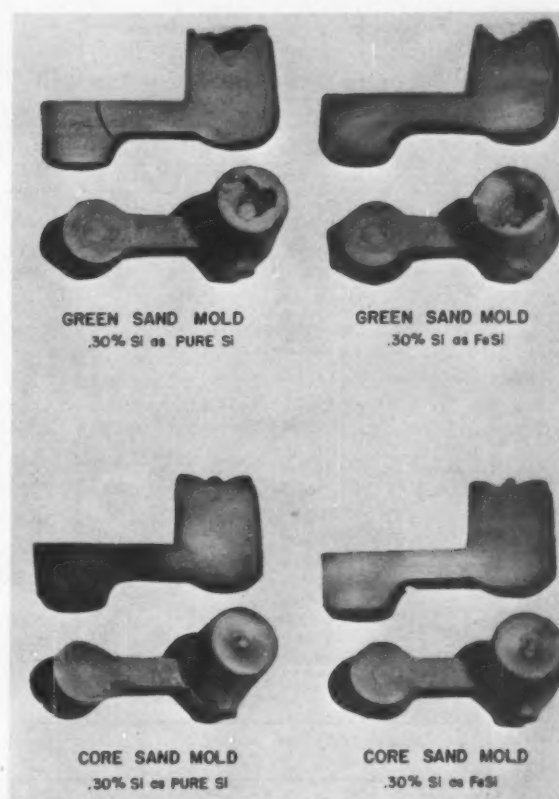
In fact, the depth of shrinkage voids in risers cast in core sand molds can be misleading, because the height of the whole riser may be reduced instead of a distinct shrinkage cavity. The deeper cavity exhibited by the risers feeding the castings in green sand is undoubtedly the result of the much greater mold wall movement experienced in green than in core sand.²³ The riser for the core sand casting is only required to feed the casting during the liquid shrinkage and shrinkage which occurs during the solidification of primary austenite.

These two contractions occur relatively soon after pouring when the riser is mostly liquid. The riser on the green sand casting, however, must also compensate for mold wall movement as well as liquid and solidification contraction. This mold wall movement occurs throughout the solidification period and the riser undergoes partial solidification during the period when this feeding of increased mold size occurs.

Mold Cavity Expansion

The results of measuring the weight and volume of the 2 in. square castings establishes that increased size of the shrinkage void that occurs in the risers with inoculation can be attributed to an increase in mold cavity expansion. The amount of increase in mold cavity enlargement depends upon the rigidity of the mold as well as the amount of inoculation. Consequently, the increase in mold wall movement is much greater in the weaker green sand mold than the stronger core sand.

The weight and volume of the 2 in. square castings, risers and casting-riser combinations, produced in the first series of experiments, are shown in Table 5, and the same data for second series in Table 6. The significant data are the effect of inoculation and



type of molding sand on the weight and volume of the casting alone. It is to be anticipated that the volume and weight of the riser would decrease, as the weight and volume of the casting increase because of greater mold wall movement.

However, the sprue and gate remain liquid for a limited period and tend to feed the riser until the top of the sprue is equal to the metal level in the riser and as long as the feed channels remain open. Consequently, the total weight of the riser and casting tends to become greater as mold wall movement increases, but the weight increase is dependent on how long the bottom of the sprue or sprue choke remains open. For this reason, the total weight of casting plus riser, and particularly the riser weight, can be erratic.

If mold wall movement is measured by the volume or weight of an unrisered casting, the effects of sprue feeding, sinks and internal shrinkage can produce misleading results. Consequently, in this work, conclusions are based on the 2 in. square bar castings only after the risers were removed. It is noted that all shrinkage voids were present in the riser in all cases, since all castings in both types of molds are completely sound.

Inoculation Effect

The effect of increasing amounts of ferrosilicon and pure silicon inoculation on the weight and volume of the green and core sand bar castings is illustrated in Fig. 3 (Series 1). This plot shows

TABLE 5 — WEIGHTS AND VOLUMES OF CASTING, RISER AND CASTING AND RISER COMBINED FOR GREEN AND CORE SAND MOLDS IN SERIES ONE

	Group									
	1	2	3	4	5	6	7	8	9	10
Casting										
Green										
Wt., gms.	6055.6	6134.9	6019.3	6148.5	6121.3	6300.5	6227.9	6264.2	6173.5	6409.4
Vol., cc.	838.1	847.7	835.9	855.3	868.7	850.2	864.4	869.6	848.4	876.6
Core										
Wt., gms.	5731.2	5629.2	5642.8	5649.6	5489.1	5624.6	5531.7	5608.1	5556.6	5552.1
Vol., cc.	791.4	776.8	780.4	783.8	756.2	779.9	768.4	768.2	770.7	771.9
Riser plus Ingate										
Green										
Wt., gms.	3388.4	3377.1	3417.9	3368.0	3368.0	3408.8	3447.4	3476.8	3424.7	3433.8
Vol., cc.	470.4	466.3	473.0	465.6	473.0	466.7	474.8	480.2	474.9	476.6
Core										
Wt., gms.	3374.8	3309.0	3331.7	3306.7	3193.3	3315.8	3243.2	3270.5	3270.5	3254.6
Vol., cc.	466.8	457.6	462.7	458.9	459.8	444.4	449.3	455.5	453.8	451.1
Casting plus Riser plus Ingate										
Green										
Wt., gms.	9444.0	9512.0	9437.2	9516.5	9489.3	9709.3	967.3	9741.0	9598.2	9843.2
Vol., cc.	1308.5	1314.0	1308.9	1320.9	1341.7	1316.9	1339.2	1349.8	1323.3	1353.2
Core										
Wt., gms.	9106.0	8938.2	8974.5	8956.3	8682.4	8940.4	8774.9	8878.6	8827.1	8806.7
Vol., cc.	1258.2	1234.4	1243.1	1242.7	1216.0	1224.3	1217.7	1223.7	1224.5	1223.0

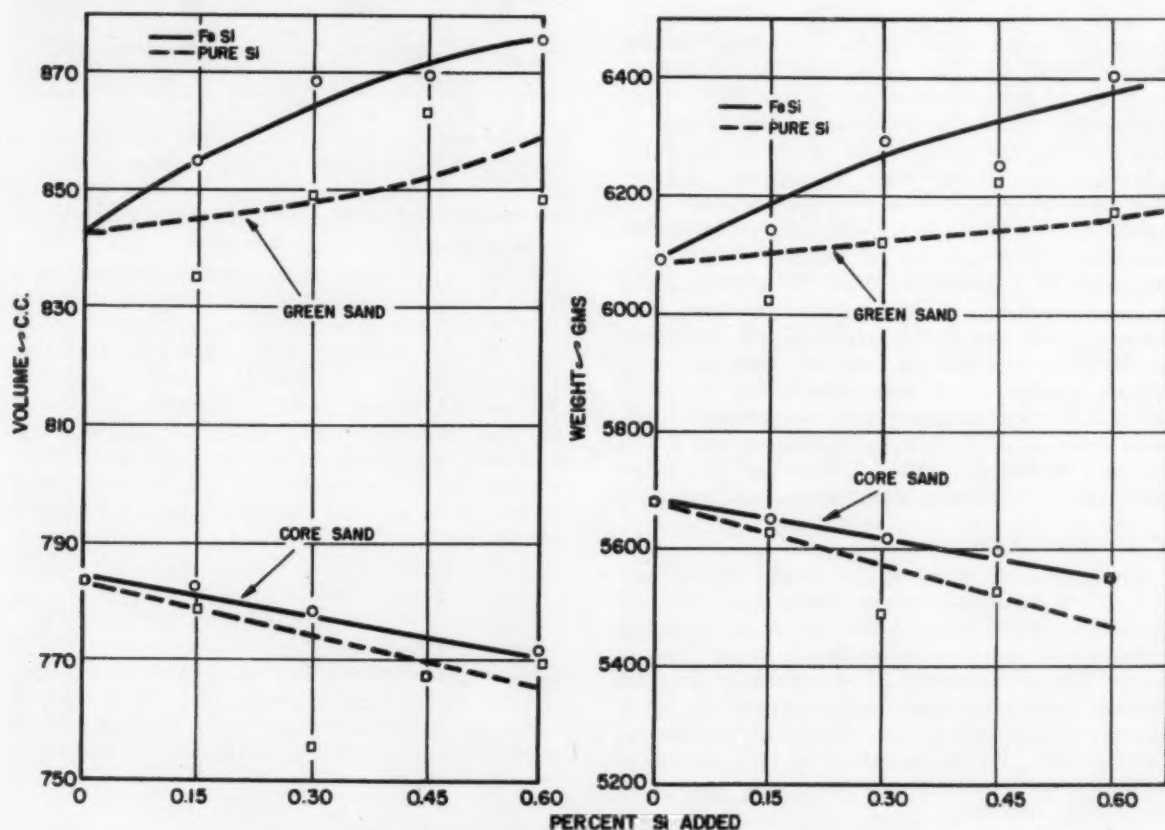
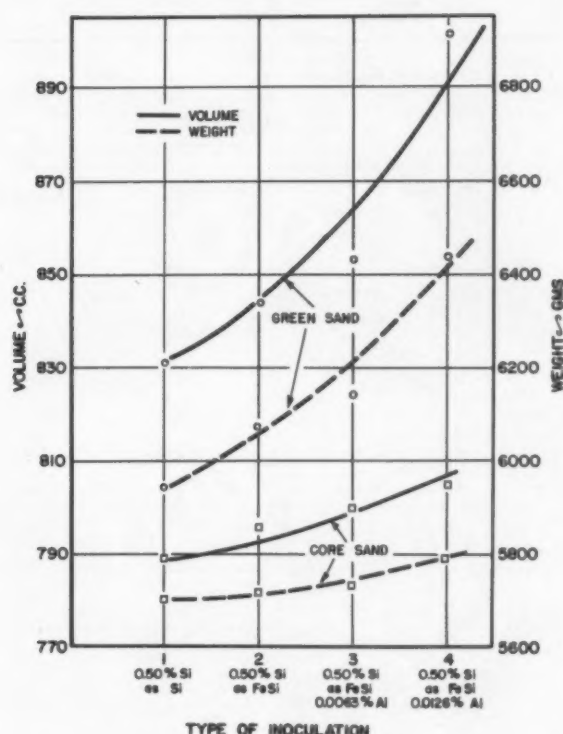


Fig. 3 — Plot of volume and weight of castings in green and core sand molds with different ferrosilicon and silicon inoculation (series 1).

Fig. 4—Plot of volume and weight of castings in green and core sand molds with various inoculants (series 2).



how increasing additions of the effective FeSi inoculant increases the weight and volume of the bar casting in green sand because of the mold wall movement resulting from inoculation. The pure silicon additions, however, do not produce much increase in the weight and volume of the castings in green sand.

In this latter case, the increased mold wall movement with increased pure silicon additions are believed to be the result of the larger amounts of graphitic carbon and eutectic from the increased silicon content. It has been shown previously that increasing graphitic carbon will increase mold wall movement.²⁴ While silicon additions are not as effective in producing more graphite as carbon additions, calculations show that silicon additions of 0.5 per cent can produce about 3.1 per cent increase in graphitic carbon in the larger amount of eutectic.

Although an equal amount of silicon was added by two types of inoculants, ferrosilicon was more effective than pure silicon in increasing the silicon content of the melt in all cases. Little difference in mold wall movement existed between the inoculated and uninoculated castings poured in core sand. The castings inoculated with ferrosilicon were only slightly larger and heavier than those with similar pure silicon additions. The weight and volume of casting and casting-riser combination actually decreased slightly with increasing amounts of both types of additions.

It appears that a much more rigid mold of the core sand eliminates mold wall movement. The authors are not able to account at the present time for slight reduction in volume with increasing silicon

content. The lower weights of the higher silicon castings can be partially explained by its lower density.

Increased Inoculation Effect

The weight and volume of 2 in. square bar castings produced in green and core sand in the second series of experiments are plotted in Fig. 4. The

TABLE 6—WEIGHTS AND VOLUMES OF CASTING, RISER AND RISER AND CASTING COMBINED FOR GREEN CORE SAND MOLDS IN SERIES TWO

	Group Number			
	1	2	3	4
Casting				
Green				
Wt., gms.	5939.9	6082.9	6137.2	6441.1
Vol., cc.	831.0	843.8	853.4	900.8
Core				
Wt., gms.	5704.0	5717.6	5733.5	5772.1
Vol., cc.	791.1	796.3	799.9	805.2
Riser				
Green				
Wt., gms.	2311.1	2005.8	2186.4	2227.2
Vol., cc.	319.5	274.1	302.2	308.5
Core				
Wt., gms.	2215.8	2274.8	2292.9	2218.1
Vol., cc.	305.1	314.3	316.4	306.3
Casting plus Riser				
Green				
Wt., gms.	8251.0	8088.7	8323.6	8668.3
Vol., cc.	1130.5	1117.9	1155.6	1209.3
Core				
Wt., gms.	7919.8	7992.4	8026.4	7990.2
Vol., cc.	1096.2	1110.6	1116.3	1111.5

TABLE 7—MECHANICAL AND METALLOGRAPHIC DATA

Group	Inoculant, %	Carbon Equivalent, %	Tensile St., psi	Bhn	Cells/sq in.	Chill Depth, in.
1	none	3.64	38,000	235*	629	—
2	none	3.57	39,800	241*	553	—
3	0.15 Si	3.64	42,900	219	879	—
4	0.15 Si as FeSi	3.66	42,900	229	2082	—
5	0.30 Si	3.67	39,300	219	1000	—
6	0.30 Si as FeSi	3.73	45,650	229	2190	—
7	0.45 Si	3.73	38,200	217	1270	—
8	0.45 Si as FeSi	3.81	45,500	232	2310	—
9	0.60 Si	3.78	37,900	217	1857	—
10	0.60 Si as FeSi	3.89	45,000	235	2660	—
11	0.50 Si	4.00	25,600**	176	925	7/16
12	0.50 Si as FeSi	3.97	28,700**	178	1510	4/16
13	0.50 Si as FeSi 0.0063 Al	4.01	29,600**	183	1810	3/16
14	0.50 Si as FeSi 0.0126 Al	3.99	33,600**	186	2025	2/16

*Some free carbide.

**Values somewhat lower than usually obtained for carbon equivalent listed. Lower results may be the result of annealing effect of riser and central location of 0.505 in. diameter test bar.

graph shows clearly that increasing effective inoculation results in considerably greater mold cavity enlargement in green sand molds. Some increase in casting size and weight was also obtained in the core sand mold, but this stronger sand was much more capable of resisting this expansion. It is evident

that aluminum shot added with ferrosilicon increased the inoculating effect, since Groups 13 and 14 show increasing volume and weight of casting as compared to Group 12. The aluminum recoveries shown by chemical analysis of these heats at such low aluminum contents were rather erratic.

The increased mold wall movement and larger apparent amount of shrinkage which occurs with inoculation indicates the influence of inoculation on the mode of solidification. The extent of mold wall movement is also influenced by a number of other variables such as temperature, composition and mold rigidity. There are indications that higher pouring temperature increases mold expansion in green sand but decreases it in dry sand;²¹ higher graphitic carbon increases mold expansion in green sand;^{23,24} and a rigid mold tends to restrict mold expansion.²³

A close control of these variables in Series 1 and 2 has made it possible to sort out the influence of inoculation on mold expansion. In the first series, the Groups 1 and 2 were intentionally poured at 2480 and 2580 F. The weight of casting at higher temperature is higher in green sand mold but is lower in core sand mold (Table 5). The pouring temperatures in this series varied between 2510 and 2540 F, and the carbon equivalent changed between 3.57 and 3.89 per cent.

The effects of these variations are evident in the scatter on plot of inoculation against mold expansion (Fig. 3). In the second series, carbon equivalent was controlled closely but temperature dropped by about 30 F from Groups 11 to 14. This, however, did not interfere with a precise correlation between inoculation and mold expansion (Fig. 4).

Tensile Strength, Bhn and Cell Count

The tensile strength, Brinell hardness number, number of eutectic cells/sq in. on the 1.2 in. bar specimen and chill depth are shown for each group of castings in the first and second series of experiments in Table 7. The tensile strength, hardness and cell count have been plotted versus the inoculation treatment in Fig. 5 for the first series and in Fig. 6 for the second series. It is evident that increasing amounts of such effective inoculants as ferrosilicon with appreciable aluminum and calcium and additional aluminum added with ferrosilicon reduce the cell size significantly.

However, pure silicon is not an effective inoculant because it does not influence the cell size appreciably. Typical uninoculated and inoculated eutectic cell distributions are shown in Fig. 7 at three and nine diameters (note scale of in. in this figure). The cells have been outlined slightly in the 3× photograph so that they may be more clearly distinguished. Effective inoculation in both series of experiments increases the tensile strength. This influence of effective inoculation is a well established fact in the literature.

However, no improvement is obtained with silicon additions in excess of 0.30 per cent silicon as ferrosilicon in the first series. The addition of alu-

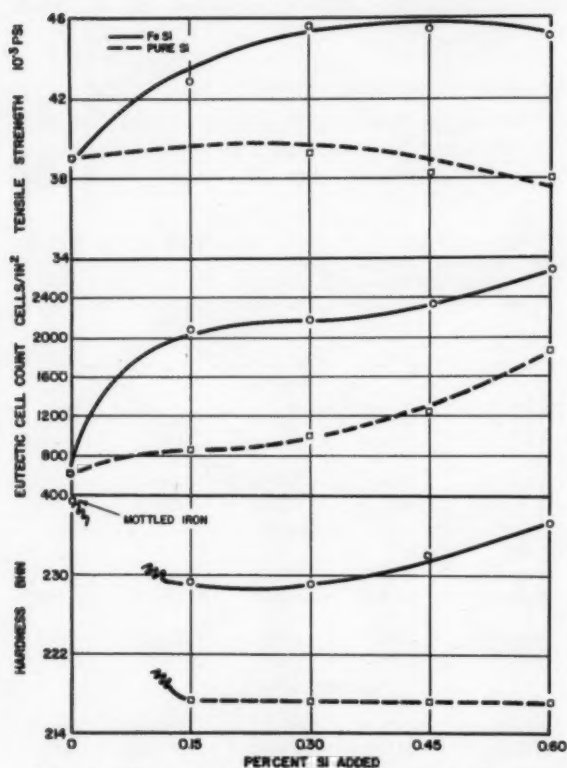


Fig 5—Plot of tensile strength, hardness and eutectic cell count vs. different pure silicon and ferrosilicon inoculation treatments (series 1).

Fig. 7—Typical cell size without and with inoculation.

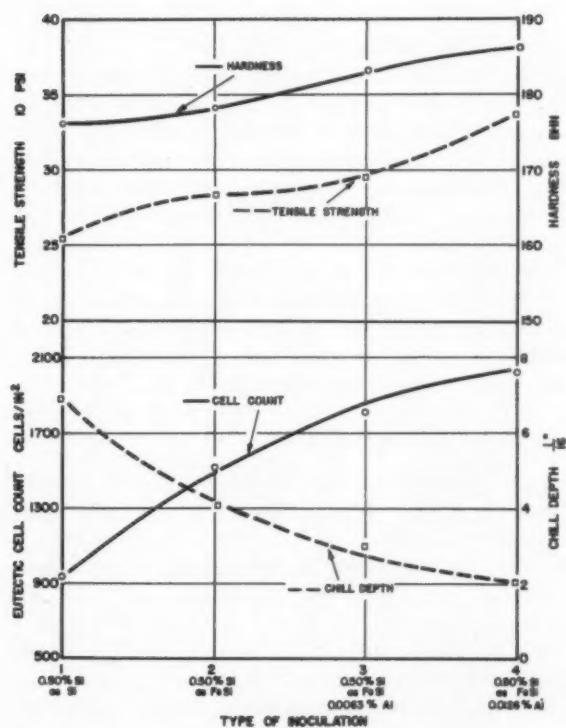
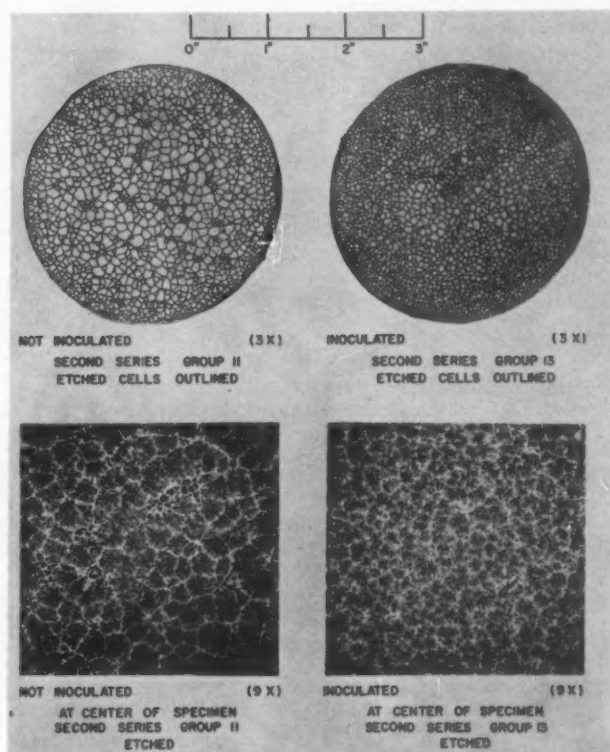


Fig. 6—Plot of tensile strength, hardness, eutectic cell count and chill depth vs. various inoculation additions (series 2).

minum with ferrosilicon results in a significant improvement in strength. The addition of pure silicon, however, slightly lowers strength, presumably because it raises the carbon equivalent and amount of graphite. The strength results on the second series are somewhat lower than usually obtained for this carbon equivalent. This lower strength may be caused by the annealing effect of the riser located near the end of the bar from which the 0.505 in. diameter test bar was removed or by the central location of this bar.

All bars were entirely free of shrinkage. The hardness is slightly increased with increasing amounts of effective inoculants. The anticipated reduction of the depth of chill obtained by effective inoculation is shown for the second series of experiments in the data of Table 7 and Fig. 6.

The type of graphitic structure varied with inoculation as was anticipated from the eutectic cell size. In the first series of experiments the initial graphitic structure of Groups 1 and 2 before inoculation was Type D with some free carbide. Inoculation with both pure silicon and ferrosilicon eliminated the free carbide. The pure silicon converted the Type D graphite to Types A and B. The ferrosilicon changed Type D to Type A with only 0.15 per cent silicon added.

Larger amounts of silicon as ferrosilicon resulted in a thicker, coarser and shorter graphite with a small eutectic cell size. In the second series, Group 11 has a mixture of Type A and Type B graphite. Groups 12, 13 and 14 had Type A graphite with flake size becoming coarser, thicker and shorter with increasing inoculation.

GENERAL DISCUSSION

Further experimentation is in progress in this investigation to establish the reasons for the increased mold wall movement resulting from inoculation. The authors appreciate that the conclusions made were reached with a limited number of castings. However, the correlation of the data were excellent. It is the opinion of the authors that the influence of inoculation on the solidification mechanism provides the explanation for this effect. Inoculation, as previously stated, reduces undercooling,² and has also been shown to increase the time required for eutectic solidification.^{2,5}

Both these factors tend to reduce the thermal gradients in the cross-section of the solidifying casting. When these lower thermal gradients occur in the presence of a larger number of effective nuclei, the result is a greater depth of partial eutectic solidification from a greater number of locations. In other words, the solidification becomes more mushy as a result of nucleation, and a mixture of solid and liquid iron extends to a greater depth into the casting. More mushy solidification requires a longer period for the formation of a solid metal skin on the casting.

The presence of a solid skin tends to reduce the mold wall movement, by increasing the resistance

of the casting to deformation under the internal pressure of late eutectic solidification. Accordingly, inoculation, by delaying the formation of a solid skin to a later period during solidification, makes the casting less resistant to internal pressures and hence more susceptible to mold cavity expansion.

Internal Pressure Increase

It is also believed that inoculation tends to increase the amount of internal pressure during eutectic solidification as well as making the casting less able to withstand this pressure. This latter effect may be explained as follows. The eutectic solidification in gray iron takes place by nucleation and growth of spheroidal shaped eutectic cells which continue to grow until they impinge upon one another. Graphite is precipitated during eutectic solidification, and because of its low density, the solidified eutectic with normal silicon contents has a larger volume than that of the liquid from which it forms.

This situation creates internal pressure acting on the casting walls. A part of this pressure is relieved by filling any internal cavities and through the riser in form of exudation, while the rest is relieved by the movement of the casting wall. When the casting is quite rigid, as in dry sand mold, the exudation in the riser becomes clearly visible, as shown in Fig. 2. The magnitude of internal pressure becomes particularly large during last stages of eutectic solidification. At this instant, eutectic cells have impinged on one another and some liquid is trapped between them.

Because of their greater surface area per unit volume, the smaller cells entrap larger quantities of liquid and restrict the movement of this liquid into the more liquid portions of the casting. In addition, a more mushy mode of freezing results in a wider region in which simultaneous liquid entrapment occurs. Graphitization of entrapped liquid exerts a pressure by means of expelled liquid iron on the solidified eutectic cells that tends to exert a pressure on the mold wall and be relieved by the movement of the wall. Finer eutectic cells and greater depth of solidification result in greater amount of entrapment, and reduction in the opportunity for the expelled liquid to purge back into the riser.

Plastic Movement of Skin

This process of liquid entrapment and pressure exertion occurs continuously along the advancing solid-liquid interface. Soon after the solid skin is formed on the surface of the casting, internal pressure may be relieved by plastic movement of the skin; but as the solid-liquid interface gets further from the casting surface, the skin becomes thick, and the opportunity for such pressure relief becomes increasingly difficult. Thus, a higher internal push in inoculated iron may be attributed to mushy manner of freezing as well as high eutectic cell count.

Since the initial work²⁶ that demonstrated the significant effect of mold wall movement on the size of the apparent shrinkage voids in gray iron, other investigators have shown how the amount of the mold cavity enlargement was influenced by foundry variables. A summary paper²⁷ has reviewed the variables reported to affect mold cavity expansion occurring in gray iron. The amount of volumetric enlargement of the mold cavity can attain values of up to 10 per cent, or can be under one per cent in some cases depending on metal and mold variables.

The increase in casting volume and larger feeding metal requirements produced by effective inoculation will, therefore, vary widely with casting conditions. With the proper type of green sand mold, the increased amount of feed metal necessary for sound castings can be minimized. Feed metal requirements can even be reduced by mold wall movement. Some evidence exists¹⁹ that the mold cavity can be decreased during pouring and solidification in chunky dry sand molds or when extensive cores are employed.

CONCLUSIONS

The increased shrinkage and riser requirements of inoculated hypoeutectic gray iron, compared to uninoculated gray iron when poured into green sand molds, are caused by greater mold wall movement. The increase in mold wall movement becomes larger with increasing amounts of inoculants. The amount of this mold cavity enlargement is much greater than can be accounted for because of the increase in carbon equivalent and amount of eutectic graphite accompanying inoculation.

A baked core (dry sand) mold is sufficiently rigid to restrict greatly or eliminate any increase in mold wall movement resulting from inoculation.

Ferrosilicon containing appreciable aluminum and calcium contents or aluminum metal added with ferrosilicon are effective inoculants of hypoeutectic gray iron as determined by eutectic cell size reduction, increase in tensile strength and reduction of chill depth. Commercially pure silicon is not an effective inoculant.

It is hypothesized that inoculation increases mold wall movement by causing a more mushy-type of solidification combined with a finer eutectic cell size. This combination produces a greater eutectic graphite push against a casting wall that is weaker for longer periods; thereby causing further outward movement of the sides of the casting.

ACKNOWLEDGMENT

The great assistance of Superior Foundry Inc., Cleveland, in producing the patterns and molds and conducting the melting and pouring operations for all castings is gratefully acknowledged. The inoculants were donated by the Union Carbide Metals, Div. of Union Carbide Corp. Mr. T. H. Bishop assisted in obtaining the required data.

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SYSTEMATIC APPROACH TO SAND DESIGN AND CONTROL

A progress report

by A. H. Zrimsek and G. J. Vingas

ABSTRACT

Foundry sand technology today lacks the ability to assign numerical values which can accurately describe sand quality and condition. Sand test values serve only as quality control tools. Present knowledge is so limited as to prohibit the use of numerical values as a basis for sand design. Sand design through application of engineering principles can come about only after systematic analysis of all variables is completed and tabulated.

This paper, which is the first of a series of papers dealing with basic properties of the various sand additives, dwells upon the major variables encountered in simple clay-sand-water systems. Subsequent papers will deal with the function of cereal, seacoal, wood flour, dextrene, etc., in foundry sands. Periodically, papers demonstrating the significance or insignificance of test results with casting results will be released. It is hoped that the series, when complete, will have provided the basics required for engineering foundry sands.

INTRODUCTION

A general lack of basic principles, concepts and especially data has prevented the treatment of foundry sands as an engineering material. A point has already been reached where improved molding machines and molding methods have surpassed the ability of our present sands to perform satisfactorily. Design of sands that can match the performance of these new machines has been reduced to a hit and miss proposition rather than elevated to an engineering problem.

This is just one of the problems confronting us. Not only are we unable to design sands because of the lack of principles and data, but we have difficulty interpreting and utilizing the test data that we accumulate during the routine quality control process. This is reflected daily in the rather high scrap rate encountered in most foundries. Steel foundries on the average scrap 40 to 50 castings per 1000, and weld over the defects on another 300 to 600.

About 40 per cent of the labor dollar in the average steel foundry is spent in the cleaning room. Although iron foundries scrap from 15 to 100 castings per 1000, their repair costs are negligible. Nevertheless, a good portion of the cost dollar can be traced to the cleaning room.

Although many would try to minimize the contribution of sand to casting defects, faulty sand de-

sign and control must accept responsibility for a good share of the difficulties. However, we are not presently in a good position to improve the situation.

Terms Used Today

Despite the reams that are published yearly relative to green sand practice, little data have been accumulated which will place foundry sands in a position of being an engineering material. The literature is full of ambiguous terms such as flowability, to temper, adequate mulling and silky feel. These terms have gained acceptance for lack of a better method of describing the many sand properties which we have been unable to describe with numerical values.

Unfortunately, there is little agreement among foundrymen as to the meaning of these terms. Numerical description of foundry sands is not only desirable but a necessity if progress in green sand practice is to take place.

There is growing sentiment among foundrymen that the present testing methods completely lack the ability to supply comprehensive data, and that new test methods and equipment must be designed. The authors feel that this sentiment is a bit premature, and that before abandoning the present procedures their case should be heard. It is felt that one point data are valueless, and that any research study on sands must be based upon systems which include combinations of variables encountered in normal foundry practice.

With the notable exceptions of the early works of Grimm, Briggs and Davies, little information dealing with foundry sands as systems is available in the literature. Despite the excellence of these early works, few foundrymen are familiar with them. Perhaps they were ahead of their time and are not readily available to the current crop of sand technicians. The authors are currently engaged in an ambitious research program which will cover and greatly expand upon the findings of these earlier works.

Studies to Be Made

All told, between 1500 and 2000 sand mixes will be studied. The variables to be considered will be clay content and type, water content, cereal, seacoal and wood flour content; combinations of clay and additives; mulling time, ramming effects and sand fineness. Properties tested are green compression, shear and tensile, rammed density, dry compression and shear. This initial research will be followed by

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TABLE 1—SCREEN ANALYSIS OF
BASE SAND USED

U.S. Standard Sieve No.	Retained, %
20.....	0.0
30.....	2.6
40.....	19.3
50.....	30.1
70.....	24.4
100.....	15.1
140.....	5.6
200.....	2.4
Pan.....	0.6

mold production by conventional and high pressure methods for possible correlation with test results.

Since the desired result of any sand research program is improved casting results metal will be cast in the multitude of molds produced, and possible correlation between casting results and sand test data will be checked. As the data are accumulated and evaluated, the number of sand tests will be broadened or narrowed as dictated by correlation with either molding or casting results.

This report, the first in a series, deals with clay-sand aggregates. Clays studied were western and southern bentonites and fire clay. Only green properties are covered by this report.

EXPERIMENT

In the initial phases of the work a single base sand is used. Its description is shown in Table 1. The great bulk of data thus far collected were obtained from sands muller in an 18 in. laboratory muller. With this muller, a batch size of 4000 grams of sand was used. Clay additions of 4.75 per cent, 7.45 per cent or 10 per cent for the bentonites were added to the dry sand, and 10 per cent and 15 per cent for the fire clay.

The mixture was dry muller 15 sec, and water was added and the mixture wet muller for intervals of 2, 4, 6 or 8 min. The muller sand was placed in airtight plastic bags and green testing done immediately. Departures from this procedure are noted in the following sections.

RESULTS

Because of the large volume of data collected, results are shown for the most part in graphical form. The great majority of data collected are depicted in Figs. 1-9. To avoid confusion, some data, especially tensile, is not shown, and its omission is noted and mentioned in the discussion section.

DISCUSSION

The advantages of studying foundry sands as systems, rather than on the basis of one-point isolated data, becomes obvious when data are assembled in graphical form as in Figs. 1-8. Not only does presentation of data in this manner allow determination of physical property trends with changes in variables, but it also allows the determination of the relationships between the various properties.

To derive full value from the data presented, the reader must first take a broad view over all the sys-

tems and then progress to narrower fields of examination. In looking over the data, it is immediately apparent that in simple clay-sand-water systems physical properties change rapidly with only small changes in water content. This is true regardless of which clay is studied or what mulling time or ramming energy is employed.

This is a display of one of the major shortcomings of clay materials. Their extreme sensitivity to small changes in water content almost prohibits any possibility of adequate control over simple clay-sand-water combinations.

Bentonite Mulling Characteristics

A second general observation that is readily made is that mulling must be considered a major variable in any system. Western bentonite is especially critical to changes in mulling. There is, in fact, a major difference in the mulling characteristics of western and southern bentonite. The effect of mulling on physical properties of foundry sands is a subject which is covered only lightly in the literature. Normally sand research is carried out under mulling conditions which are termed adequate.

A comparison of Figs. 4 and 5 shows that the difference in mulling characteristics of western and southern bentonite does not allow a comparison of the two materials on a basis of a single mulling time simply described as adequate. At this early stage of the project, the authors are hesitant to discuss the term adequate mulling.

The term cannot be defined in terms of minutes mulling, but must ultimately be defined as the mulling time required to bring a particular combination of sand, water and additives to a condition that will produce the best molds and, of course, the best castings. At this stage it cannot be assumed that this condition is obtained only (if at all) through extensive mulling.

Variable Mulling Cycles

Further study of the systems obtained by variable mulling of the 7.4 per cent western and southern bentonite mixes brings out several interesting items. As mulling time is reduced, points of maximum compression and shear and minimum rammed density are shifted to higher water contents. Although the maximum compression and shear values obtained are substantially reduced by short mulling, the minimum rammed density obtained is unaffected although shifted to higher water contents.

Whether bonded with western or southern bentonite, the effect of mulling changes on physical properties of sands is reduced as water content is increased. The commonly accepted idea that southern bentonite imparts higher green compression strength than western can be traced directly to the difference in mulling characteristics of the two materials. Actually, western imparts higher compression at both high and low water contents if mulling is extended to extremely long periods, as shown by the supplementary data in Table 2.

The futility of measuring flowability by methods which are based on comparison of rammed densi-

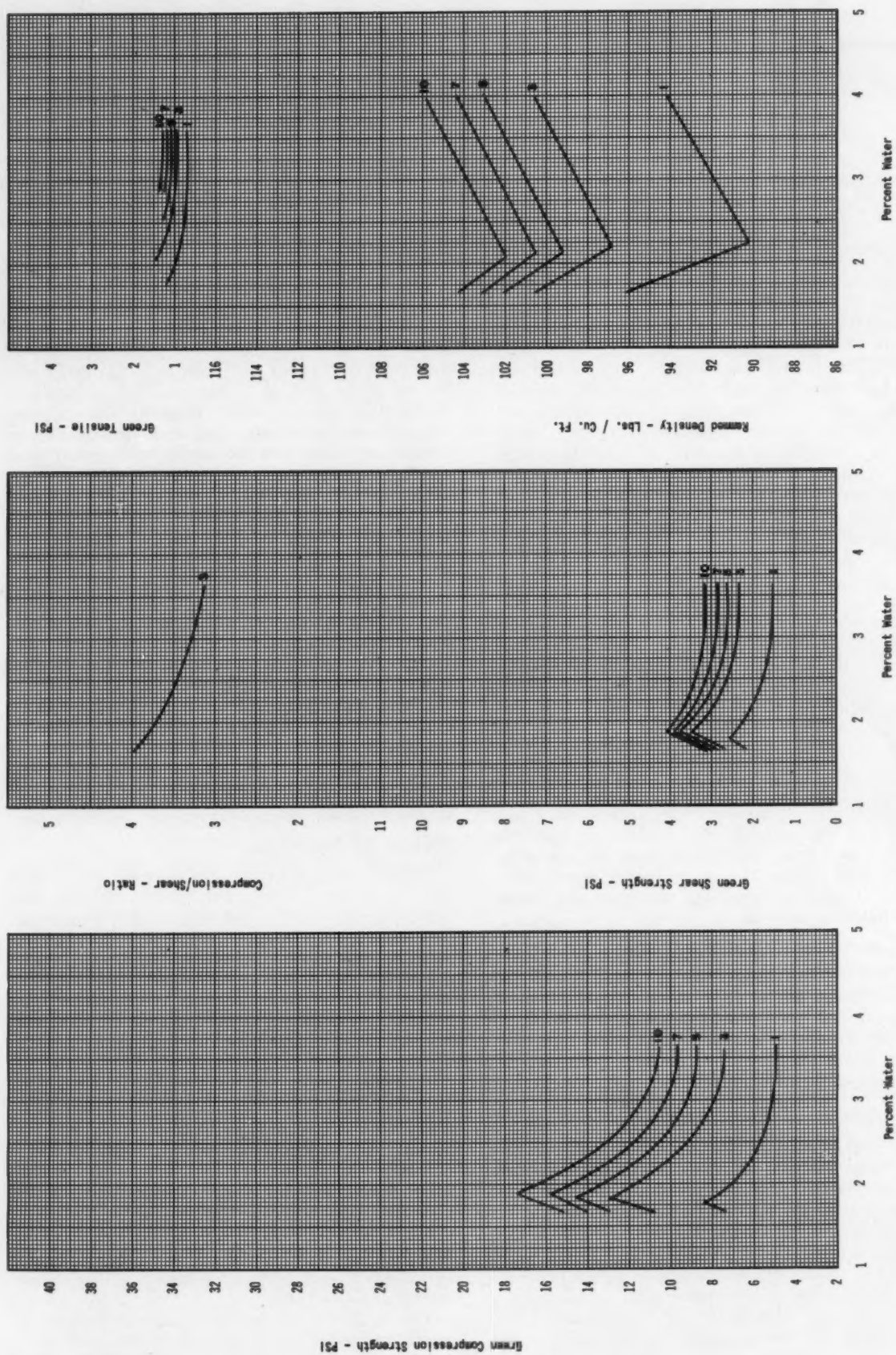


Fig. 1—Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

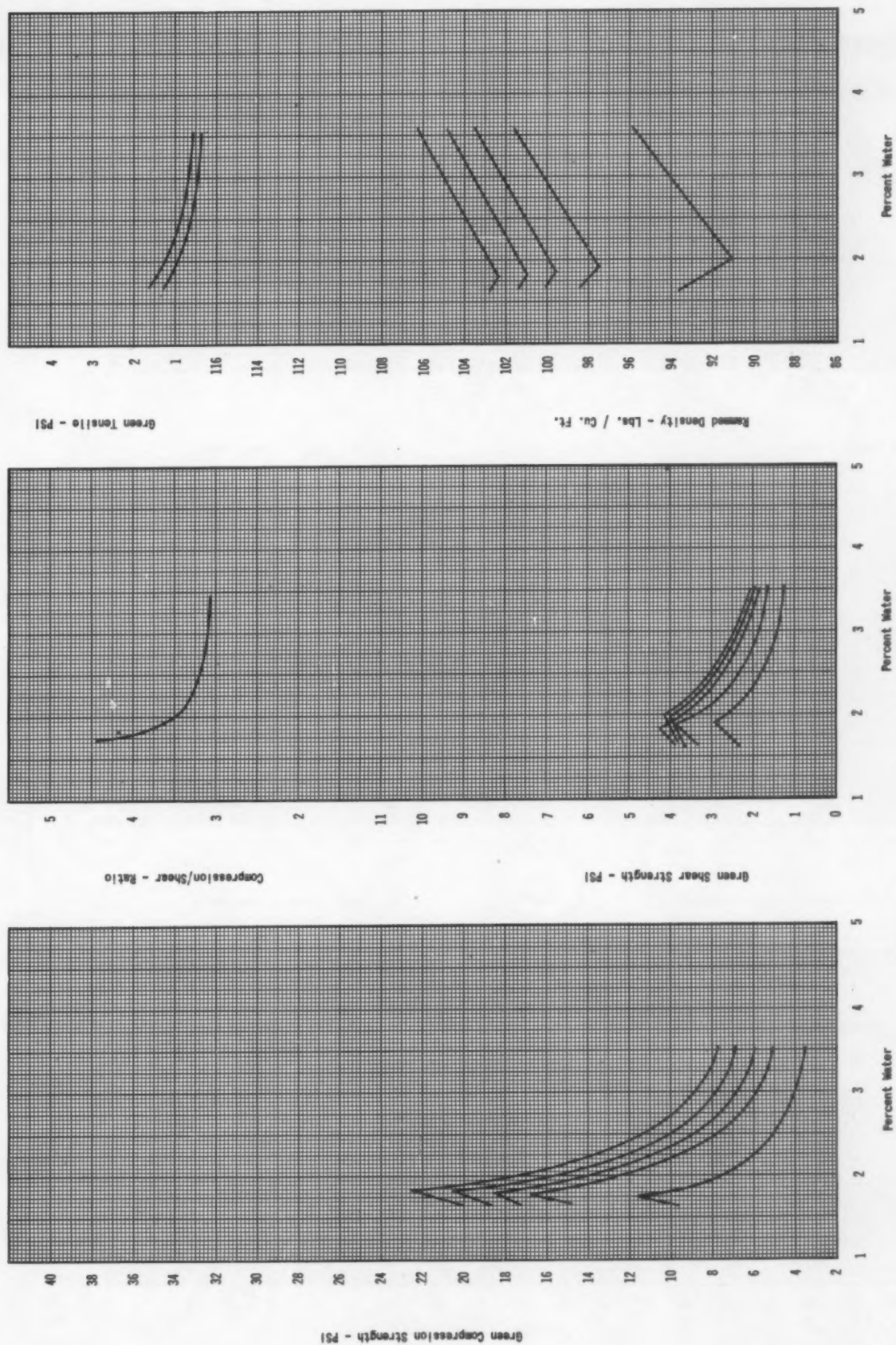


Fig. 2—Water content and ramming energy effect on physical properties of 4.75 per cent southern bentonite bonded Portage silica sand. Milled 6 min.

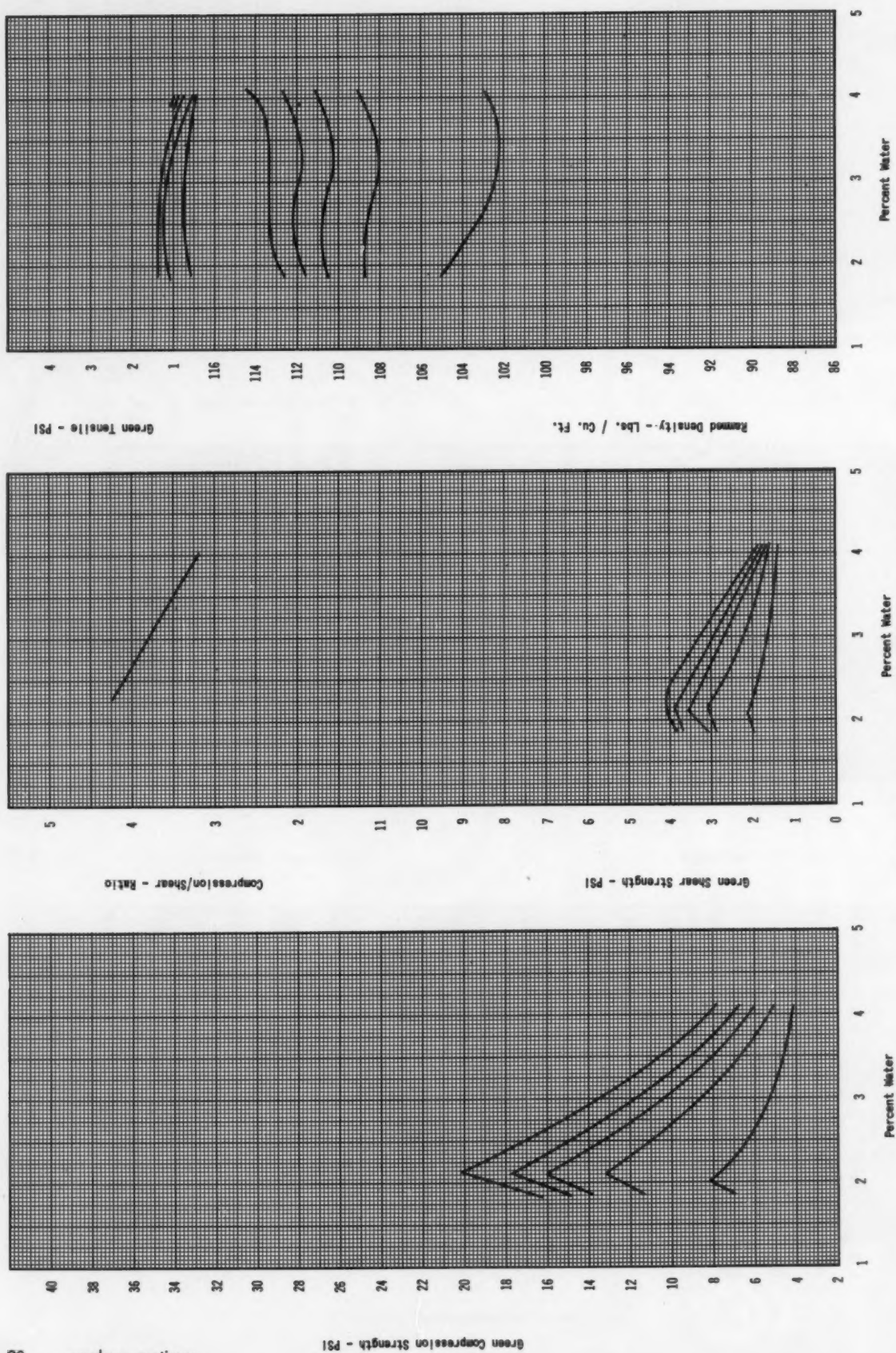


Fig. 3 — Water content and ramming energy effect on physical properties of 10 per cent fire clay bonded Portage silica sand. Muddled 6 min.

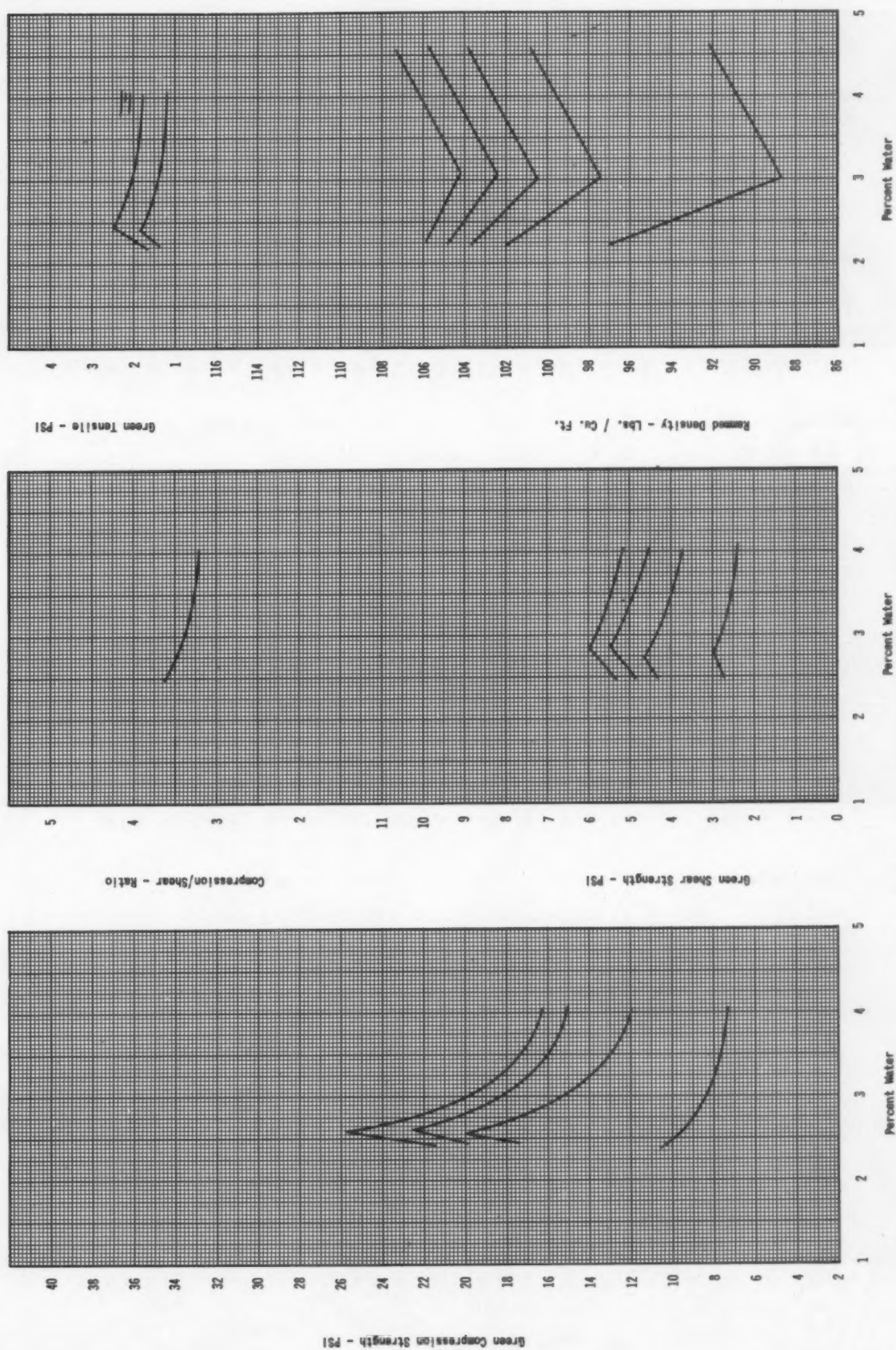


Fig. 4a — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Milled 6 min.

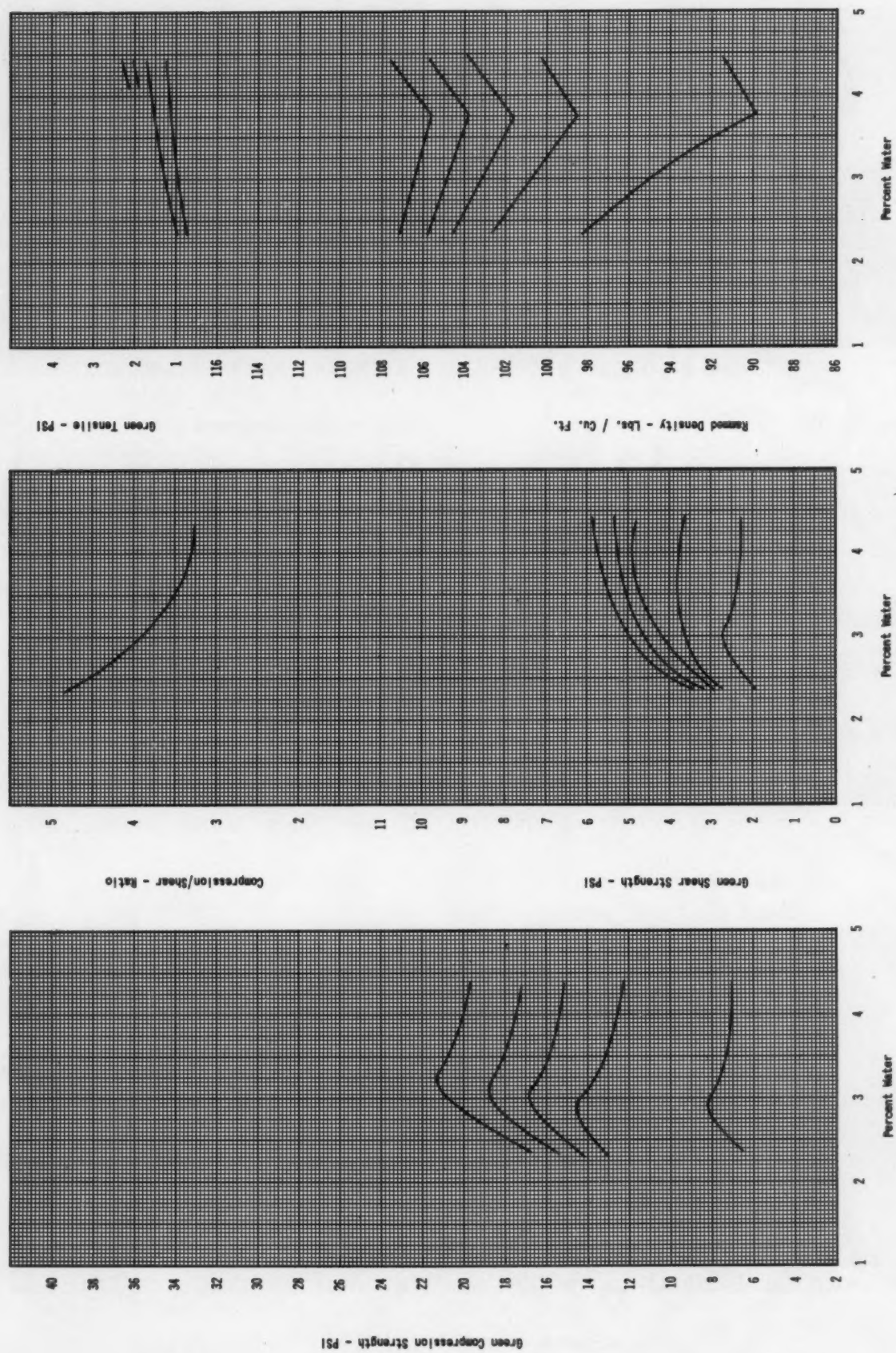


Fig. 4b — Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Mulled 4 min.

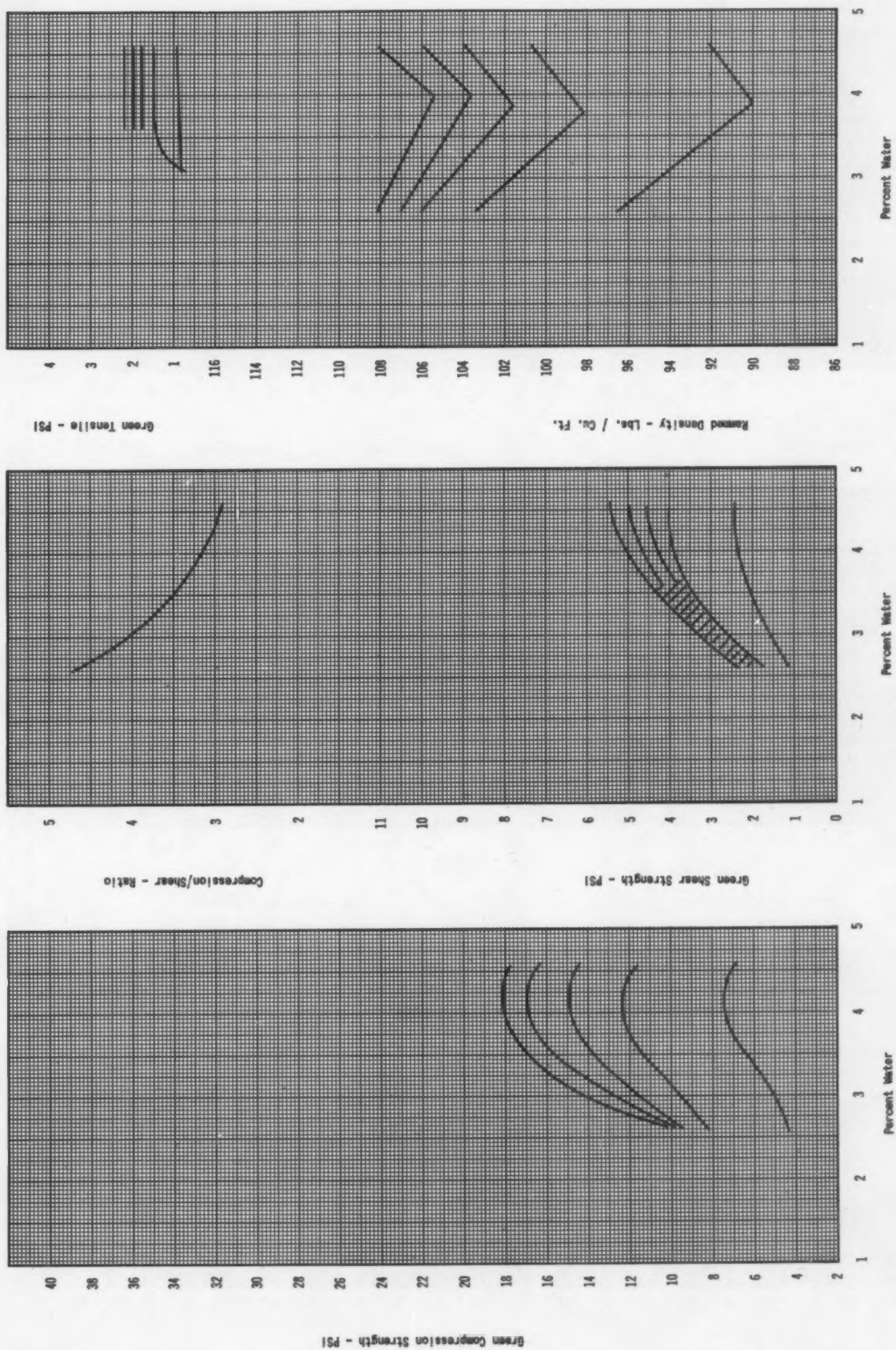


Fig. 4c— Water content and ramming energy effect on physical properties of 7.45 per cent western bentonite bonded Portage silica sand. Mulled 2 min.

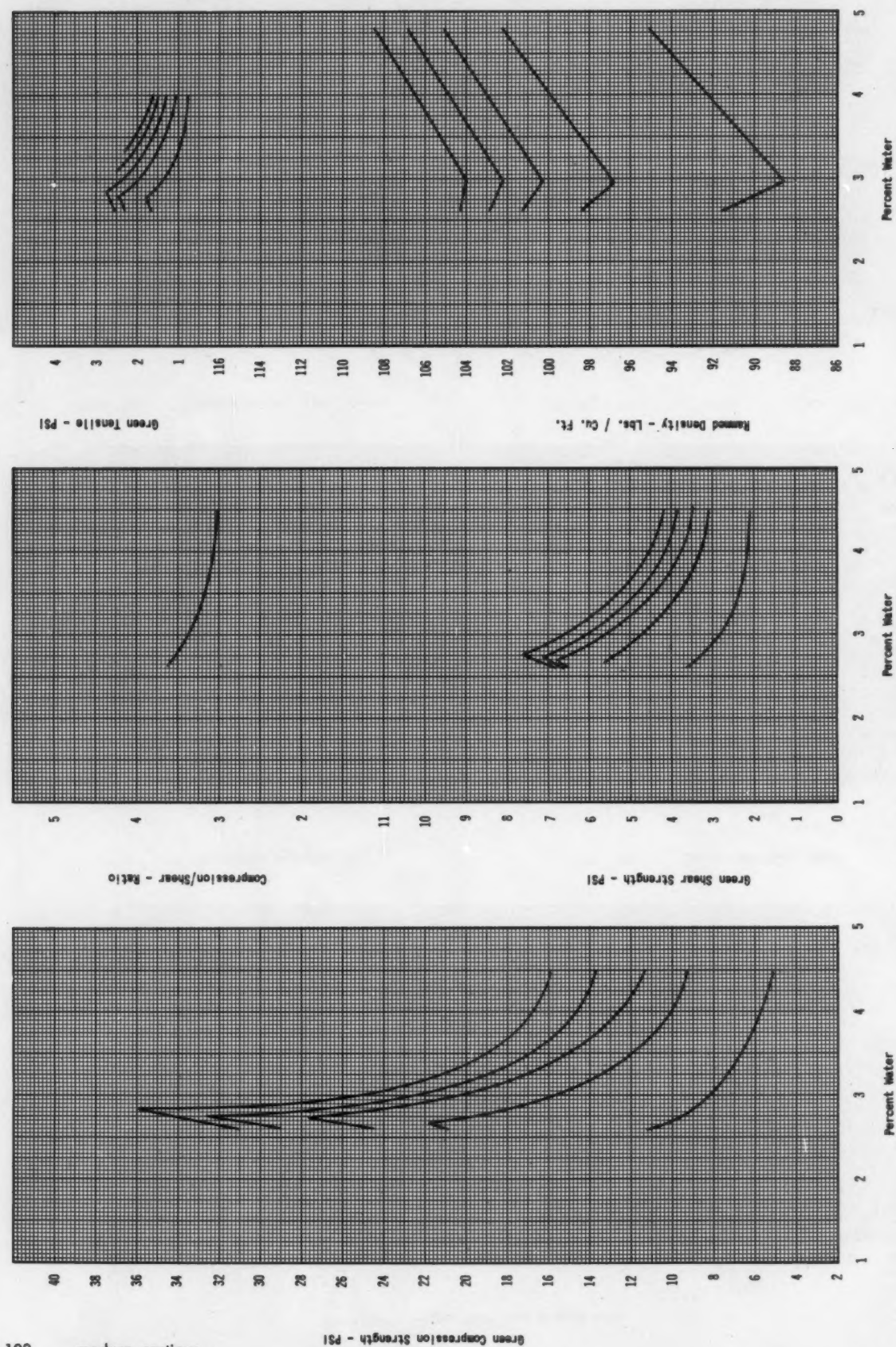


Fig. 5a — Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Mulled 6 min.

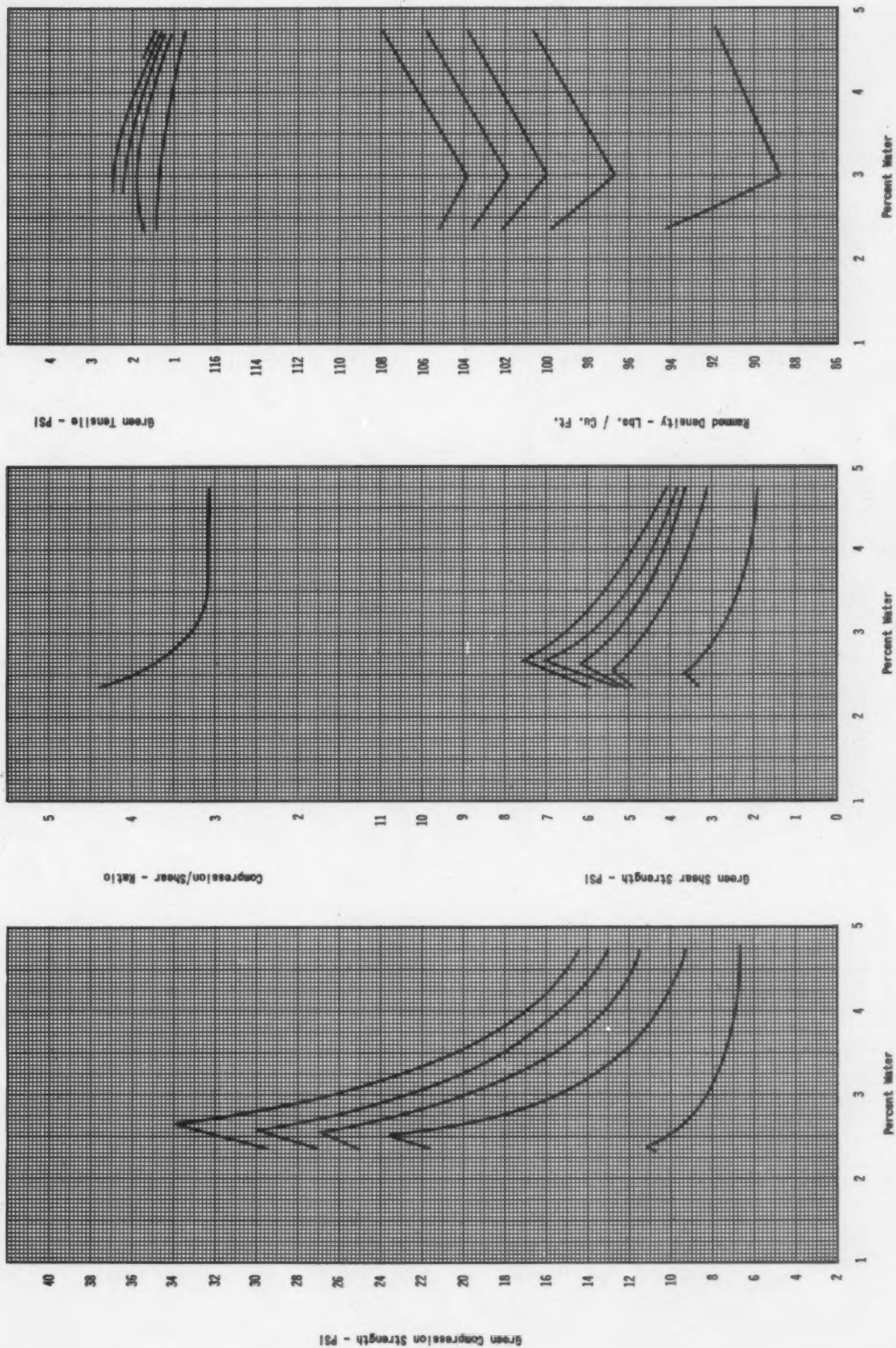


Fig. 5b—Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Mulled 4 min.

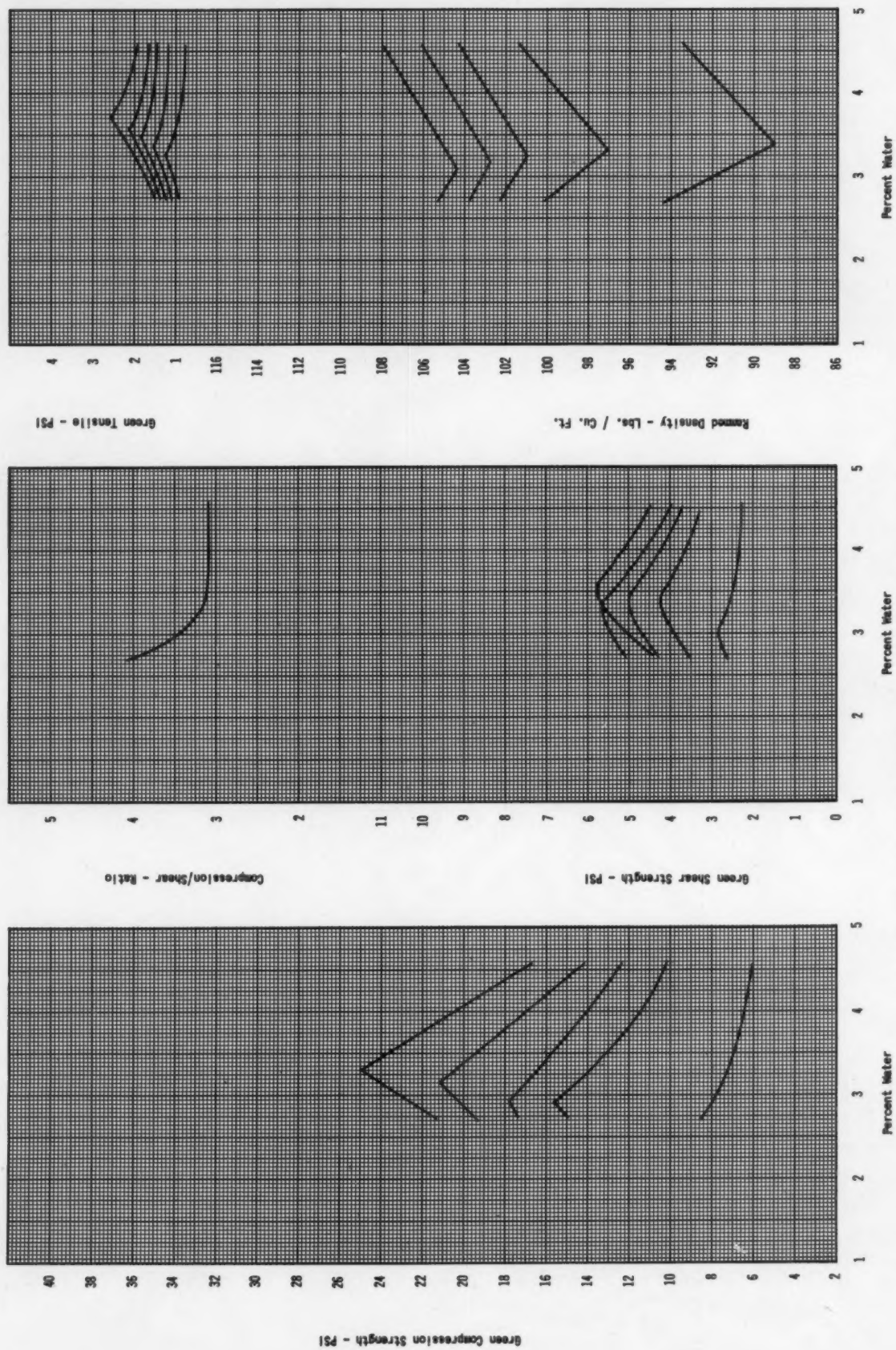


Fig. 5c—Water content and ramming energy effect on physical properties of 7.45 per cent southern bentonite bonded Portage silica sand. Milled 2 min.

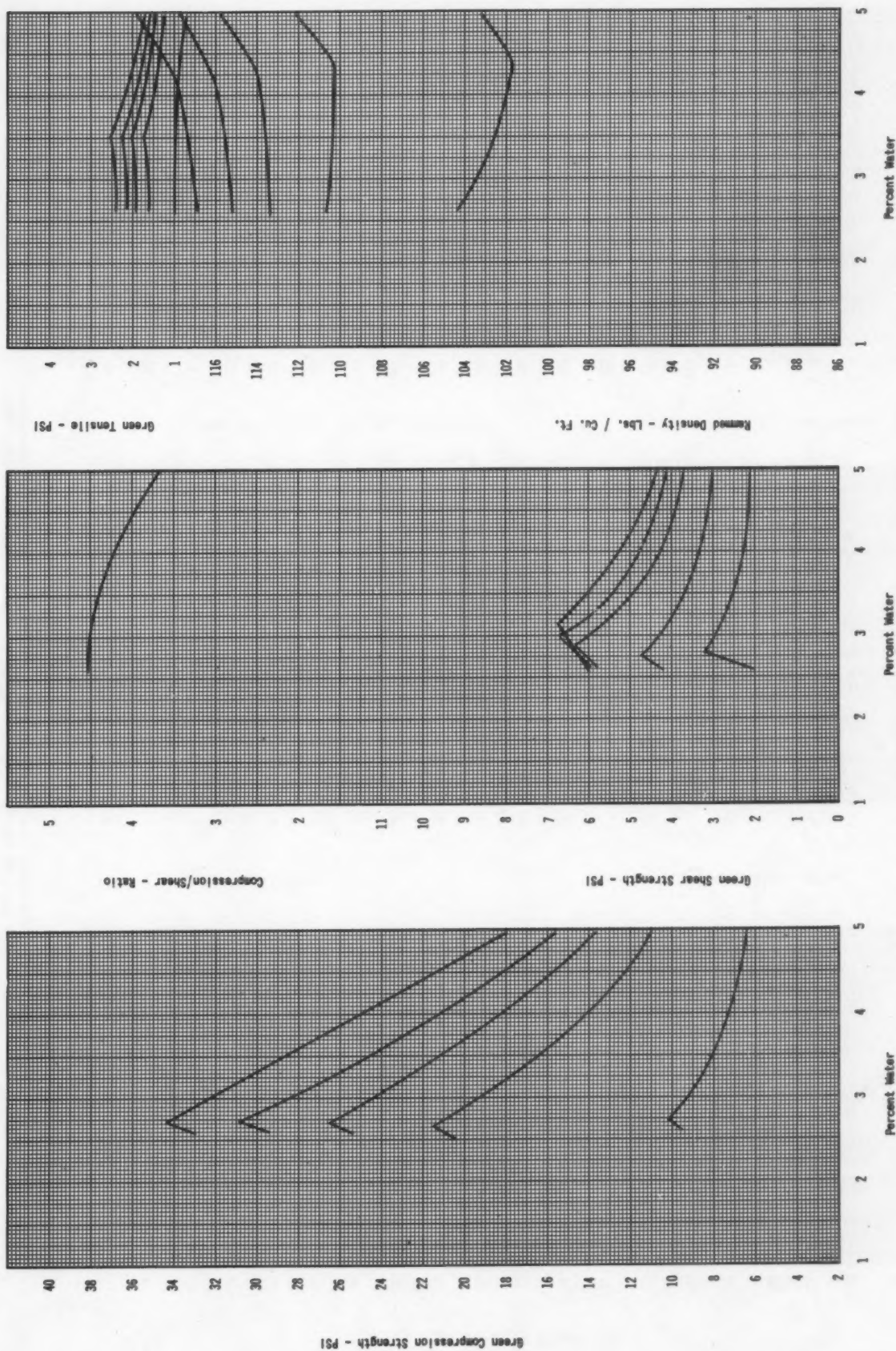


Fig. 6— Water content and ramming energy effect on physical properties of 15 per cent fire clay bonded Portage silica sand. Milled 6 min.

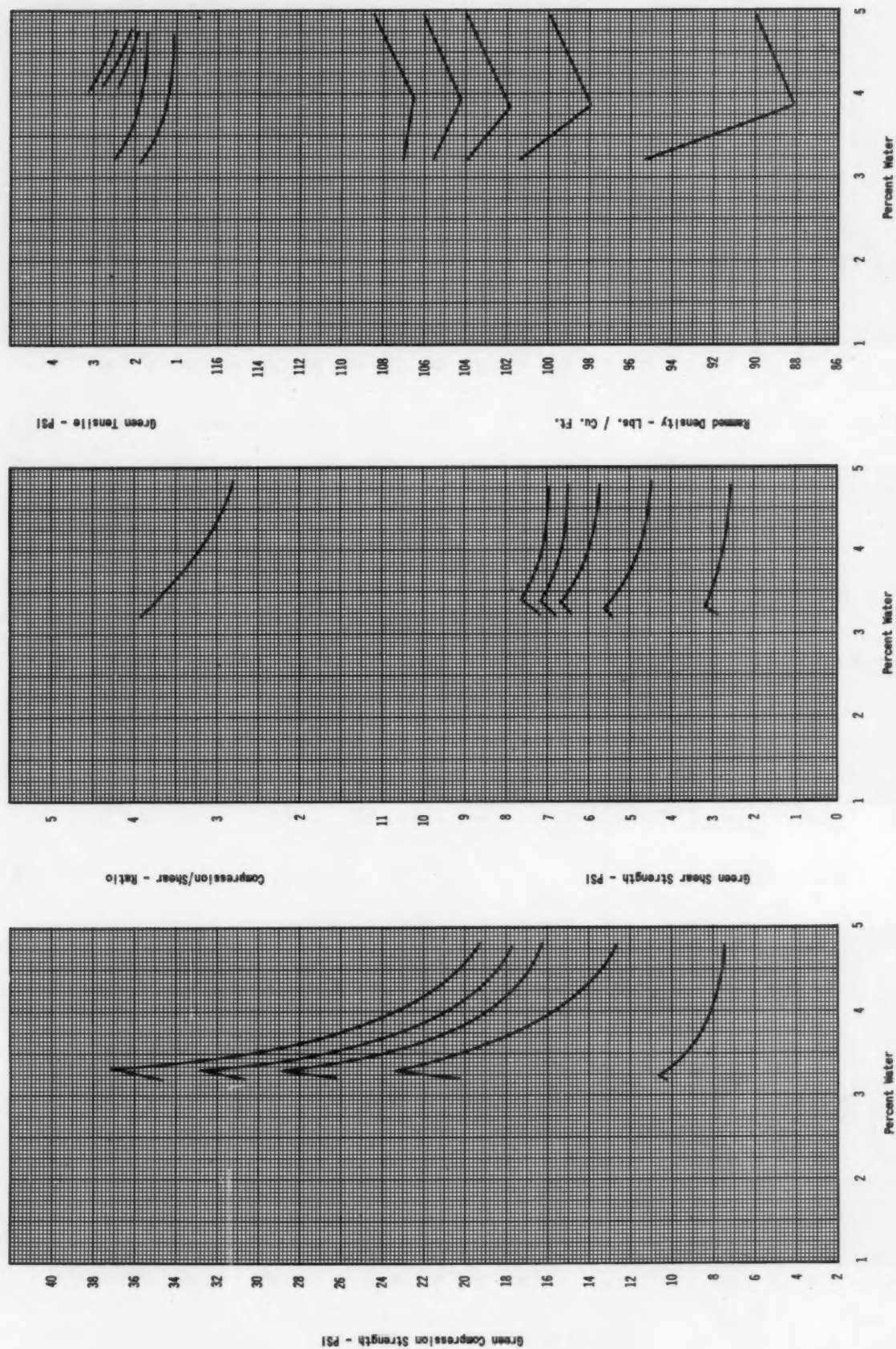


Fig. 7 — Water content and ramming energy effect on physical properties of 10 per cent western bentonite bonded Portage silica sand. Muddled 6 min.

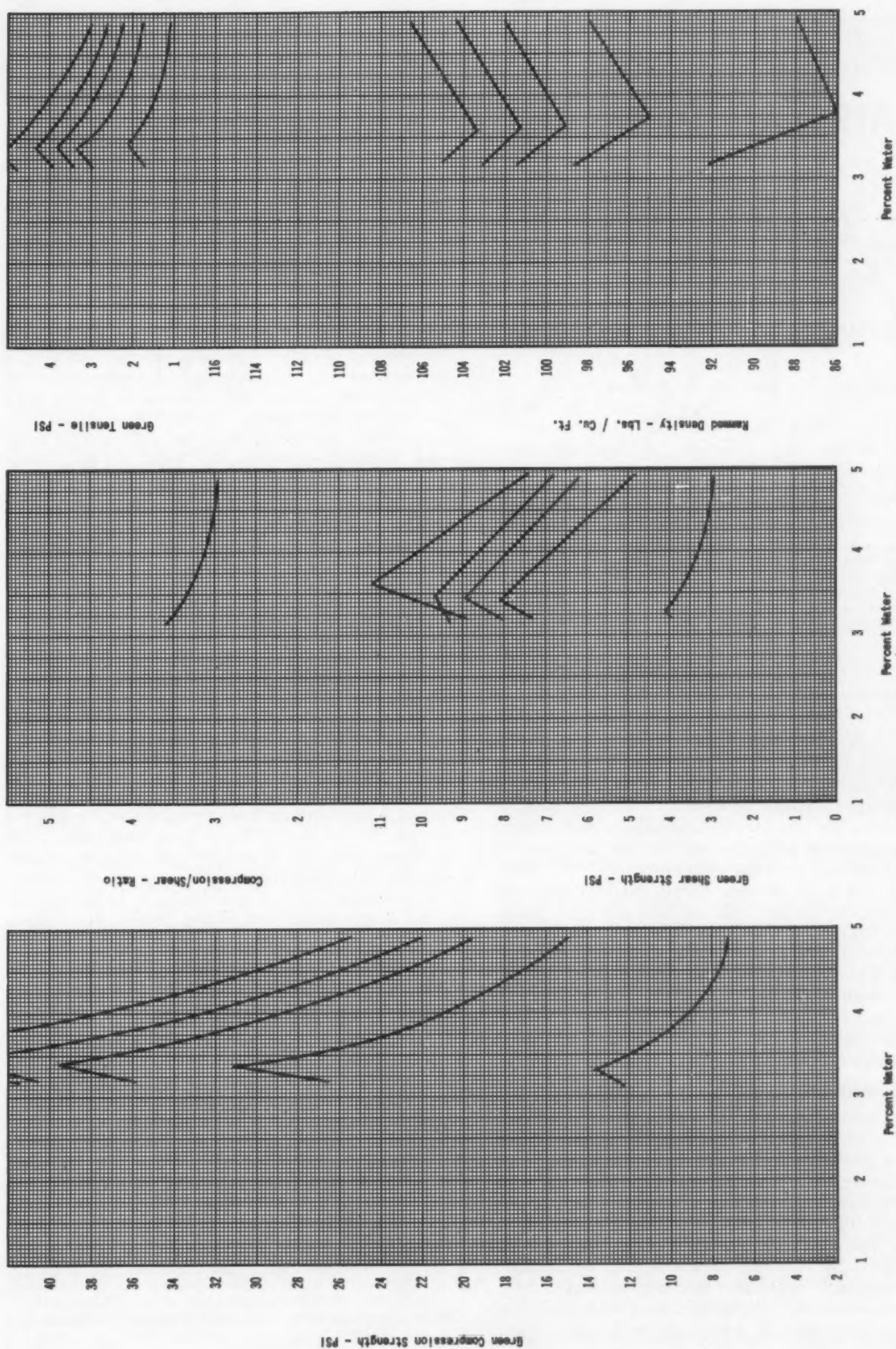


Fig. 8 — Water content and ramming energy effect on physical properties of 10 per cent southern bentonite bonded Portage silica sand. Muddled 6 min.

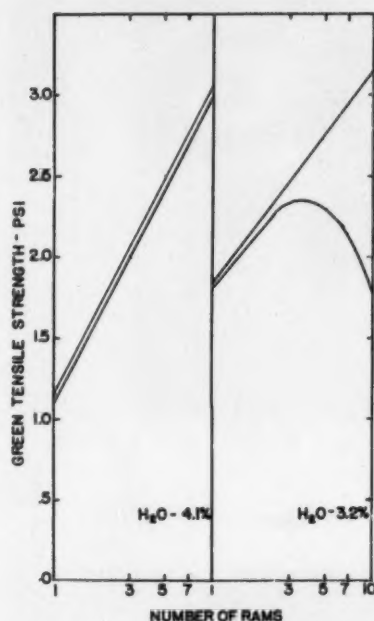


Fig. 9 — Example of sands bonded with 10 per cent western bentonite possessing predictable and unpredictable tensile strengths. Tensile strengths of sand at right are erratic beyond 3 rams.

TABLE 2

Mulling time effect on 3 ram green compression strength of sand bonded with 7.4% western bentonite, 2.6% H ₂ O.	
Mulling Time, min	G.C.S., psi
2.....	8.2
4.....	14.0
6.....	18.8
12.....	25.2

ties between the fourth and fifth ram is shown by the data. If the point of minimum density is considered the most desirable temper point, it is seen that the change in density between four and five rams, or one to ten for that matter, is equal for both western and southern at each clay content, and that mulling time does not affect the relationship.

Fire clay at 15 per cent and 10 per cent resembles bentonites at 7.4 per cent and 4.75 per cent, respectively. Since all density lines at a given clay content are parallel for all water contents beyond the minimum point, flowability measurements based on rammed density comparisons will remain constant as water content is increased. Flowability would also be independent of mulling. This is not consistent with the experience of most foundrymen.

Green Strengths Ratio

The reader will notice that the ratio of green compression to shear strength at three rams has been included in the graphical representations. The exact significance of this ratio is, at this time, not completely understood. However, it can be said that generally a high ratio indicates a brittle and flowable sand. This is an observation that is not only substantiated by the data presented, but by measurements made in many iron and steel foundries.

Steel foundries, for example, work with sands that have a compression to shear ratio of between 2.5 and

3.0. Steel foundry sands are quite gummy. Iron foundries, on the other hand, use sands that are quite brittle in comparison. The ratio normally encountered there lies between 3.75 and 4.5. The ratio is incapable, in its present form at least, of detecting anything other than gross changes in feel.

It does not, for example, describe the difference in plasticity of low and high clay contents or the difference in plasticity imparted by bentonites and fire clay. For clay-sand-water systems, the point of minimum density falls with fair consistency at a water content at which the ratio is approximately 3.25-3.5. Increased clay content allows production of sands with increased green compression strength while maintaining plasticity.

It is possible, for example, to obtain a three ram compression of only 7.8 psi at a ratio of 3.25 at 4.75 per cent western bentonite. At 7.4 per cent and 10 per cent western bentonite, compression values of 13 psi and 16 psi, respectively, are obtained at the 3.25 ratio. This comparison might be construed to mean that the compression to shear ratio can be used as a tool for proximate analysis of clay content in foundry sands.

The reader will, of course, wish to draw his own conclusions from the data presented, but is cautioned not to jump to hasty conclusions or form firm opinions until the work progresses and is reported in subsequent progress reports. The object of the series is to present data and concepts which are not only basically sound, but which also will find practical foundry application.

Tensile Data

In the plots of tensile data, only data which showed progressively higher values as ramming increased from one to ten rams are included. Where data for the higher ramming energies are omitted, values became erratic and unpredictable. In Fig. 9 a sample of the predictable and unpredictable values is shown. Until molds and castings are produced, the authors will reserve judgment as to whether unpredictability is a sign of over-ramming and coincident with broken molds and casting defects. It is apparent, however, that low clay content and low water content contribute significantly to the unpredictability.

CONCLUSIONS

The authors do not wish to draw any firm conclusions at this point of the project. The reader is reminded that this is a progress report, and that the data presented are only a small fraction of the total to be presented.

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PRECISION CASTING MOLD MATERIALS

by W. G. Lawrence

ABSTRACT

Various types of inorganic binders are discussed with particular emphasis on their chemical formation and high temperature properties. Differential thermal analysis is valuable in the determination of baking temperature required to eliminate refractory composition gaseous products. Mold dimensional stability is determined, for the most part, by aggregate characteristics, with some contribution from the binder (which depends on the original mix bond and liquid percentage).

INTRODUCTION

Any precision casting investment material must have the following desirable characteristics:

- 1) Sufficiently high temperature stability to withstand contact with metal at the pouring temperatures involved.
- 2) Ability to harden or set from a workable pouring consistency in a controlled period of time.
- 3) Simplicity in compounding, mixing and pouring operations.
- 4) A minimum of dimensional change during the setting, curing and pouring cycles, or at least a constant and reproducible change.
- 5) Economically practical.

HIGH TEMPERATURE MOLD MATERIALS

The materials used for the casting of the various types of irons, steels or the other types of metals such as titanium or zirconium will be considered in this high temperature category.

There are many aggregates which will stand the temperatures involved in these types of castings including silica (SiO_2 , 3130 F), alumina (Al_2O_3 , 3720 F), chrome oxide (Cr_2O_3 , 4410 F), magnesia (MgO , 5070 F), zirconia (ZrO_2 , 4870 F), mullite ($3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$, 3290 F), forsterite ($2\text{MgO} \cdot \text{SiO}_2$, 3434 F), zircon ($\text{ZrO} \cdot \text{SiO}_2$, 4532 F), calcined clays (3200 F), spinel ($\text{MgO} \cdot \text{Al}_2\text{O}_3$, 3875 F), or if one wishes to consider materials other than oxides there are at least 14

nitrides with melting or decomposition temperatures above 3000 F and 16 carbides in the same category.

Unfortunately, one must consider many factors other than melting point when selecting an aggregate for a precision casting material.

Thermal Expansion Characteristics

Does the material have a smooth thermal expansion curve, or does it pass through crystal inversions on heating which may tend to cause cracks in the mold resulting in casting defects? This tendency is particularly exaggerated in larger molds where the temperature gradients involved in the curing process are large. For this reason, in recent years the tendency has been to replace the silica type aggregate (Fig. 1) with the materials which have a uniform thermal expansion curve being preferred. Materials such as the aluminosilicates, alumina, zircon or the noncrystalline low expansion aggregate such as silica glass are often used.

Availability in Proper Particle Size Ranges

If a material is not available in the proper size ranges there is no need to consider it further. This eliminates many of the synthetic materials such as the carbides, borides or nitrides. Particle size dis-

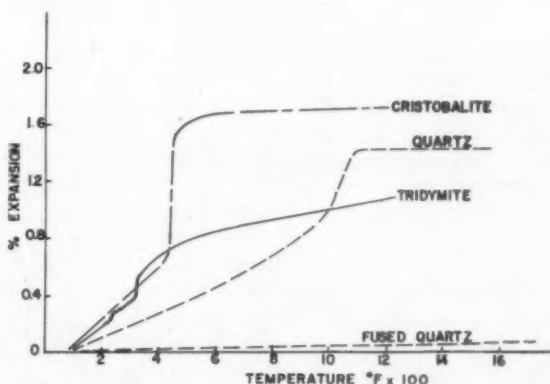


Fig. 1 — Thermal expansion of various forms of silica.

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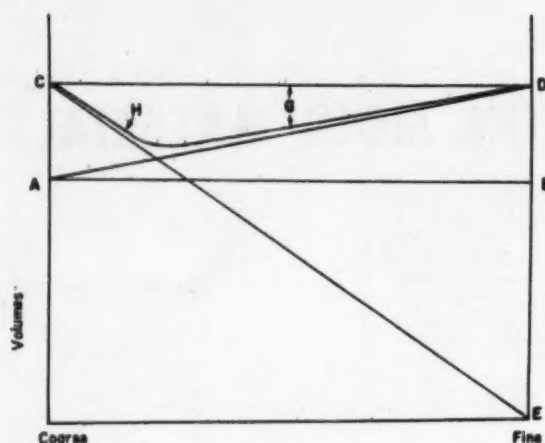


Fig. 2 — Packing diagram of two component system. *H* represents actual curve of apparent volume. *G* represents shrinkage of volume during mixing.

tribution and the packing of particles is overlooked much more than it should be in the fabrication of mold materials.

The aggregate is the best part of any investment mold. Most of the troubles come from the bonding material. It makes sense that the smaller the percentage of bond material and the lower the percentage of liquid required to produce a pouring mix, the less will be such variables as shrinkage during curing, setting expansion or shrinkage, reproducibility of dimensions and casting defects. Again this problem is minimized with small castings and magnified in large ones.

In single size component systems the voids may be 45-50 per cent, in two sized component systems 35-40 per cent (Fig. 2) and in three sized component systems approximately 22 per cent (Fig. 3). Since all voids must be filled with binder and water to produce a pouring mix, and these are the components which must be later removed by drying

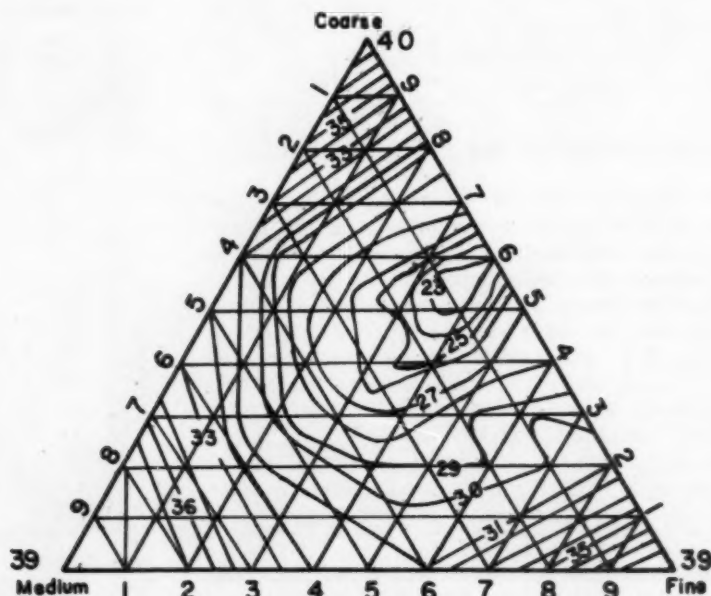
or stabilized by some heat treatment with the resulting dimensional change, the smaller the amount required the better.

Data on ethyl silicate-silica investments show that the particle size distribution of the aggregate which produces the closest packed system requires the least silicate solution and produces the greatest strength.

Thermal Conductivity

Thermal conductivity of precision casting mold materials is of great importance, much more than people realized a few years ago. The relationship between hot tearing and cooling rate has been pointed out by Christopher.¹ The use of investment type mold materials in cores or restricted sections would have been thought impossible a few years ago, due to the high hot strength of these materials as compared to the conventional types of dry or green sand molds.

Fig. 3 — Packing diagram for ternary mixtures.



Surprisingly these materials produce sound castings, and often these materials enable the foundryman to produce castings impossible by any other method. This is due to the much lower thermal conductivities of the investment type materials as compared to sand molds. This, in turn, results in a lower thermal gradient within the metal section resulting in less stress. The great difference is shown by the following data for two types of mold materials, dry sand and an ethyl silicate bonded investment.

	K cal/sec/cm/C	C _p	ρ	Freeze Time
Dry Sand	0.0037	0.28	1.5	1
Ethyl Silicate Investment	0.0009	0.18	1.5	5.7

It is due to this 6-fold decrease in the freezing time of the metal, with the resulting lowering of temperature and stress gradients within the metal during the "slushy" solidification stage, that makes possible the production of castings in investment materials not otherwise possible in conventional sand molds.

Figure 4 graphically illustrates this effect for a sphere of varying diameter and also illustrates the advantageous effect of pouring molds hot other than to prevent misruns.

HIGH TEMPERATURE BINDERS

Ethyl Silicate

The esters of silicic acid were the first organic silicon compounds to achieve importance. Monomeric ethyl silicate and its polymers are now large tonnage industrial chemicals manufactured by a continuous process by reaction between silicon tetrachloride and ethanol. The ability of ethyl silicate to deposit silica from solution makes it useful not only in the precision casting field but as impregnants or adhesives in other areas.

There are three types of ethyl silicates available; the tetraethyl orthosilicate $(C_2H_5O)_4Si(28\% SiO_2)$, condensed ethyl silicate $(28\% SiO_2)$ which is a mixture of the tetraethyl orthosilicate with some polysilicates and ethyl silicate 40 which is a mixture of polysilicates. Its name arises from the fact that it contains approximately 40% SiO_2 .² Because of the lower cost per unit of available SiO_2 , the condensed and ethyl silicate 40 are used in the precision casting field.

The steps necessary in the use of ethyl silicate for precision casting binders have been described.³ The exact techniques used probably vary with each individual manufacturer, thus the procedures described must be taken as general, not specific.

Assuming ethyl silicate 40 is used as the starting materials, one must hydrolyze this solution and cause it to react with water in order to produce a solution which will deposit the adhesive form of silica desirable for the bonding of refractory aggregates.

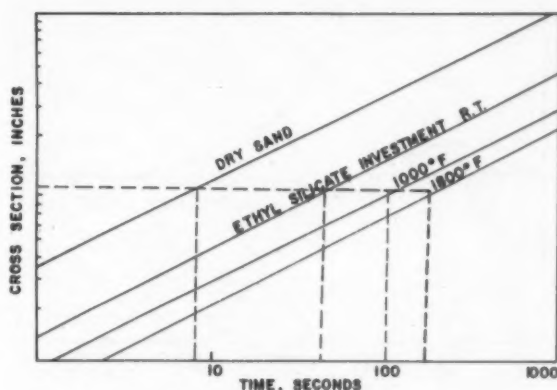
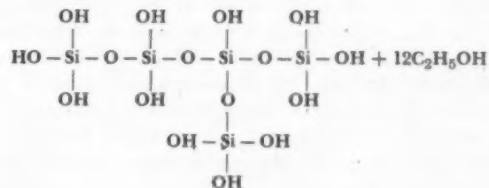
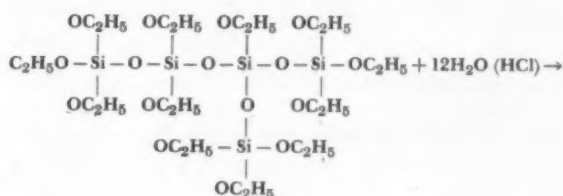


Fig. 4 — Freezing time of sphere.

The hydrolysis reaction may be written as follows:



To bring out this hydrolysis the following mixture is recommended:

Ethyl Silicate 40, %	37.6 (volume)
190 proof ethyl alcohol, % ..	59.8
3% HCl, %	2.6

Anhydrous Solution

This mixture should be allowed to stand with occasional agitation for at least 2 hr before use to insure complete hydrolysis. This is called an "anhydrous" solution since only enough water has been added to complete the hydrolysis process. Such solutions are stable and may be stored for reasonable periods without deterioration or gelling providing excessive evaporation of the alcohol is prevented.

There are many ways which may be used to promote gelling of the anhydrous solution, and all depend upon pH control and the addition of excess water. The pH of the anhydrous solution approaches 1-2. As the pH is raised the gelling or set time will be decreased. At a pH of 6 the gelling time must be 60-90 sec.

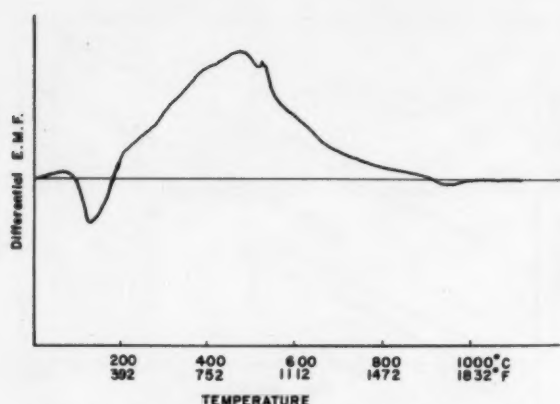


Fig. 5 — Differential thermal analysis of silica — ethyl silicate mixture.

For a desired setting time of 50-60 min the following mix is recommended:

Aggregate (SiO ₂)	99.6
MgO	0.4
100 vol. anhydrous solution	
6.5 vol. water	21.0

In this instance the MgO acts as a neutralizing agent for the HCl, gradually raising the pH and causing the precipitation of Si(OH)_x and the gelling of the mixture. Because of the action of the MgO, care must be taken to insure its even distribution in the mix, otherwise hard and soft areas will appear in the mold.

The percentage of the anhydrous solution used varies widely. For maximum strengths the maximum amount should be used with little or no water added, and the setting time controlled by the addition of salts of strong bases and weak acids. In cases where small castings are being made in flasks with wax patterns high strengths are not necessary and dilution with water and slow setting times are desirable. For larger castings where patterns must be drawn from precision molds, often with back-drafted rubber patterns, high strengths and shorter setting times are desirable and necessary.

Setting Time Control

As indicated previously the setting time is easily controlled by the addition of salts of strong bases and weak acids. NaOH and Na₂CO₃ may be used but are rather difficult to control. Ammonium salts are more easily controlled such as NH₄OH, (NH₄)₂CO₃ or the ammonium-organic salts such as the amines may be used. This is a basis on which patents have been issued on the Shaw process.

Some of the materials suggested are piperidine, morpholine or triethylamine. Percentages recommended vary depending upon type of aggregate, previous dilution of the anhydrous solution, mixing time required, working time desired and other

unknown factors, but the percentages of the amines used varies between 0.1 and 1 per cent by volume based on the volume of the anhydrous silicate solution.

During the setting process it is desirable to vibrate in order to release trapped air bubbles as well as to pack the aggregate into its most dense arrangement with a minimum of bond thickness between grains.

Since the fine particle size investment with the precipitated bond between grains has a low permeability, precautions must be taken to insure proper curing of the mold previous to metal-mold contact. Here again requirements vary depending on pouring temperature, casting section and mold section.

For small castings using permanent patterns ignition of the alcohol immediately after the pattern is stripped is sufficient. The burning of the alcohol on the mold surface generates sufficient heat to dehydrate the silica bond and remove any water from the mold surface. Certain claims are also made that this burning-off process also creates a fine crack pattern which increases the permeability of the mold allowing for the escape of gases when the metal enters the mold cavity.

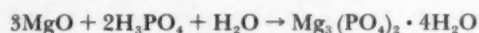
For "lost wax" patterns such a procedure is not possible since the pattern must be removed by heating, the wax burned off and the mold surface dehydrated.

The thermal analysis curve (Fig. 5) for a ethyl silicate bonded aggregate probably gives the best indication of what occurs when such a material is heated. This curve shows an endothermic peak at approximately 212-230 F due to removal of excess water from the mold. This is followed by an exothermic reaction due to the burning of the alcohol. Superimposed on this reaction is another unknown reaction taking place at approximately 932 F. At 800 C (1472 F) all reactions are completed and no further change takes place. The aggregate is now bonded with SiO₂, stable up to temperatures approaching its melting point of 1710 C (3110 F) or lower depending upon the type of aggregate used with it.

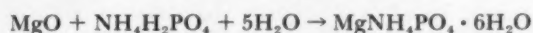
PHOSPHATE BINDERS

A number of phosphates have been used for the bonding of refractory aggregates including the aluminum, calcium, magnesium, zinc and lead phosphates. The one of most interest to the precision casting process is the magnesium phosphate bond.

This bond may be formed simply by the reaction between MgO and H₃PO₄.



Due to the industrial hazard involved in using phosphoric acids other phosphates are used such as di-hydrogen ammonium phosphate.



This reaction governs the setting of phosphate in-

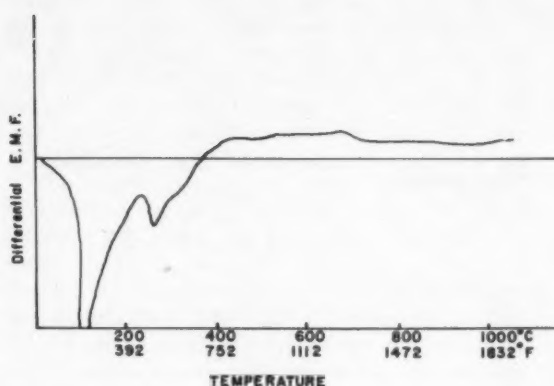


Fig. 7 — Thermal expansion of $\text{MgO}-(\text{NH}_4)_3\text{PO}_4-\text{SiO}_2$ refractory.

vestments. The setting time is controlled by the grain size, surface area and degree of calcination of the MgO . Because of this controllable feature the manufacturer may vary the setting time. Most commercial phosphate bonded investments have setting times of 15-30 min. Boric acid acts as a retarder, 0.25 per cent will double the setting time.

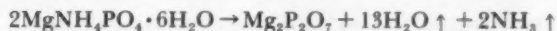
The usual commercial phosphate binders contain approximately 41% MgO , 59% $\text{NH}_4\text{H}_2\text{PO}_4$. The investment composition would approximate:

Aggregate	80 parts
Bond	20
Water	15-25

Since these materials are sold compounded ready to mix with water, their use is simple and fool-proof.

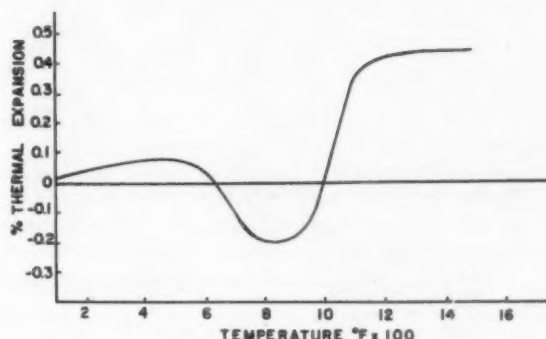
Curing of Phosphate Bonded Investments

After the set the mold is cured by heating. The magnesium ammonium phosphate bond which is hydrated must be decomposed to the pyrophosphate bond before pouring the metal.



The differential thermal analysis curve (Fig. 6) for such a bond indicates two main endothermic peaks at 230 F and 527 F which are due to the removal of water and ammonia, respectively. Indica-

Fig. 6 — Differential thermal analysis of silica — $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$ mixture.



tions are that such molds baked at 600 C (1100 F) should contain no gaseous products.

At 2510 F, $\text{Mg}_2\text{P}_2\text{O}_7$ decomposes to release P_2O_5 gas. This is the upper limit for the use of this bond and accounts for the rough surface which is sometimes experienced when using this type of material for metals with pouring temperatures in the 2500 F region.

The thermal expansion of the magnesium ammonium phosphate type of investment is shown in Fig. 7. It should be noted that shrinkage occurs in the region where the ammonia is being evolved from the bond. Following this shrinkage an abrupt rise in thermal expansion occurs in the temperature region where a crystalline inversion takes place in the silica aggregate. This abrupt rise would be absent in a material containing an aggregate such as Al_2O_3 , as shown in Fig. 8.

CALCIUM ALUMINATE CEMENTS

There are two calcium aluminate compositions, $\text{CaO} \cdot \text{Al}_2\text{O}_3$ and $\text{CaO} \cdot 2\text{Al}_2\text{O}_3$ stable at 1600 C (2912 F) and 1720 C (3128 F), respectively. Both of these materials are hydraulic setting, and may be used as bonding materials for other refractory aggregates.

The $\text{CaO} \cdot 2\text{Al}_2\text{O}_3$ composition, although it has the higher melting point which is desirable, has some undesirable features, particularly its slow setting time and low strength development for the time involved in normal foundry mold production.

The $\text{CaO} \cdot \text{Al}_2\text{O}_3$ composition has fast setting characteristics and develops excellent strength in short periods of time. The setting time is controlled by

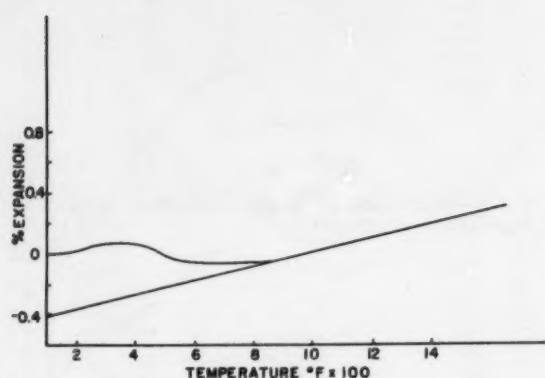
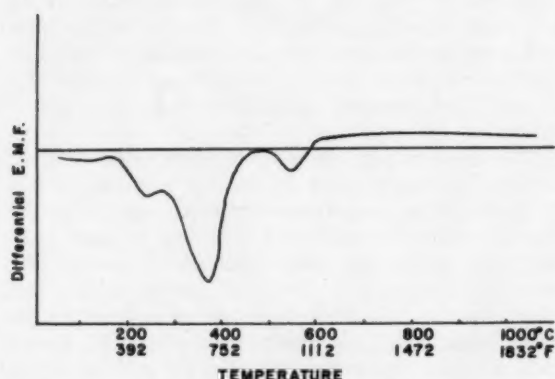


Fig. 9 — Setting time of $\text{CaO} \cdot \text{Al}_2\text{O}_3$ refractory.



varying the temperature of the ingredients before mixing, particularly the water temperature (Fig. 9).

A typical mix using calcium monoaluminate is as follows:

Aggregate	60-80 parts
CA Cement	20-40
Water	30-50

The setting of calcium aluminate cements is not unlike cements of the Portland type. It is a reaction with water which produces a gelation and hardening.

The differential thermal analysis of the set $\text{CaO} \cdot \text{Al}_2\text{O}_3$ previously dried at 212 F is shown in Fig. 10.

The thermogram indicates that there are prob-

Fig. 8 — Thermal expansion of $\text{MgO}-(\text{NH}_4)_3\text{PO}_4-\text{Al}_2\text{O}_3$ refractory.

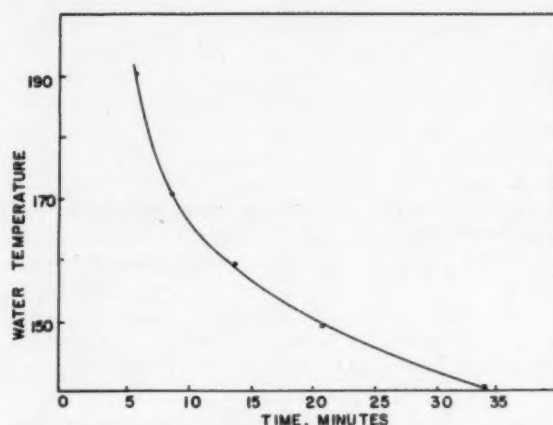


Fig. 10 — Differential thermal analysis of $\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Aq}$ cement.

ably two hydrated compounds involved. The first compound to dehydrate is probably the major component ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{aq}$) which begins its dehydration at 175 C (347 F) and is decomposed completely at 490 C (914 F). The double peak is characteristic of the two stage dehydration of some natural hydrated calcium minerals such as gypsum.

Water Evolution

Evolution of water begins from a minor constituent which may be $\text{CaO} \cdot 2\text{Al}_2\text{O}_3 \cdot \text{Aq}$ at 490 C (914 F) and is complete at 600 C (1112 F). From this temperature to 1832 F there is no further evidence of any reactions.

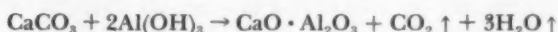
Based on this analysis baking temperatures in the

700-900 C (1300-1600 F) range should be sufficient to prevent casting defects due to mold gases.

The $\text{CaO} \cdot \text{Al}_2\text{O}_3$ cement has one disadvantage in that the hydration reaction is exothermic which results in considerable temperature rise. This effect is not serious in small cross-sections, but may become a problem in large masses of investment.

The thermal expansion curve for a calcium aluminate-silica material is shown in Fig. 11. As may be seen, this curve shows no abnormal dips or rises other than the abrupt rise in the 1000 F region due to the crystal inversion in SiO_2 . Some shrinkage occurs above 1400 F, but not excessive.

$\text{CaO} \cdot \text{Al}_2\text{O}_3$ is made by the solid state reaction between calcium carbonate and aluminum hydrate by the following reaction:



The proper proportions of calcium carbonate and aluminum hydrate are mixed and heated to a temperature of 1850-2000 F. Reaction occurs between the freshly formed CaO and Al_2O_3 . The material is a white powder, requires no grinding or sizing and is ready for use.

This is an excellent high temperature bond, dimensionally stable, simple to use and satisfactory up to temperatures of 2700-2900 F depending upon the aggregate.

ALUMINUM ACETATE PROCESS

It is possible by proper chemical control to precipitate metal hydroxides from any of the soluble metal-organic salts. For example, by using a soluble aluminum acetate and raising the pH one can precipitate alumina gel $\text{Al}(\text{OH})_3$ which acts as a binder for the refractory aggregate. One of the most effective methods of doing this is to use a MgO addition as is often done in the ethyl-silicate process. Again the rate of set is controlled by the fineness, surface area and degree of calcination of the MgO used. As the pH of the solution is changed in the vicinity of the MgO grain surface, alumina gel precipitates and setting occurs. Since the bond is hydrated it must be heated to form alumina according to the reaction:



Figure 12 shows the thermal analysis curve for an Al_2O_3 - MgO -aluminum acetate mixture after setting. The dehydration of the alumina gel occurs at approximately 700 F followed by a high exothermic peak due to the formation of crystalline Al_2O_3 . The curve indicates that molds cured at 1100 F should be gas free and suitable for precision casting molds. Since the bond is Al_2O_3 it has good high temperature properties.

The MgO addition required to set the bond has a tendency to flux silicate or alumino-silicate minerals therefore use is restricted to 2700-2800 F with

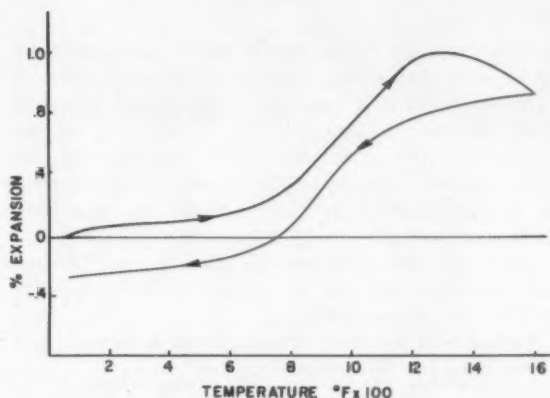


Fig. 11 — Thermal expansion of $\text{CaO} \cdot \text{Al}_2\text{O}_3$ — silica refractory.

these aggregates. If aggregates such as MgO (dead burned) or forsterite ($2\text{MgO} \cdot \text{SiO}_2$) are used the fluxing action is eliminated and the mold will be usable for higher pouring temperatures. Similar techniques may be used to form oxide bonds such as ZrO_2 from zirconium acetate or other metallic oxides from soluble metallo-organic compounds.

"GLASCAST" PROCESS

The original "glascast" process, as developed by the Corning Glass Works, was one involving a cope and drag type of mold. This type mold was made by drain casting using plaster of paris molds as are used in the slip casting of other types of ceramic bodies. The material used for this type of process was the high silica glass powder "vycor" which has a composition 96% SiO_2 , 2.5% B_2O_3 , others 1.5%. Since it is a glass, not a crystal, the coefficient of expansion of this material is low being $4.7 \times 10^{-7}/\text{F}$.

For making the mold a slurry is prepared of 4 parts "glascast" powder to 1 part of water (by weight). This is poured into the plaster of paris mold, allowed to set for a certain time depending upon the wall thickness which one desires to build up and then drained. The green strength of the mold is believed to be due to the soluble silica, and the fired strength is developed due to the sintering of the fine glass particles. Molds are fired

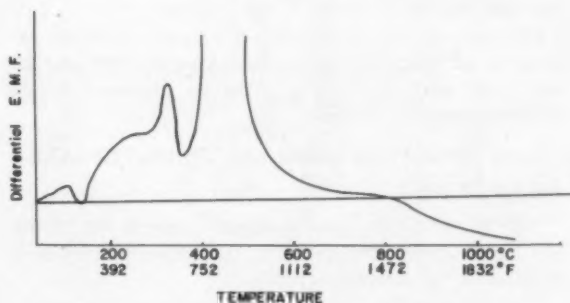


Fig. 12 — Differential thermal analysis of $\text{MgO} - \text{Al}(\text{C}_2\text{H}_3\text{O}_2)_3 - \text{Al}_2\text{O}_3$ refractory.

to 1050 C for 15 to 20 min to insure uniform heating. Drying and firing shrinkages are negligible.

Obviously such a method using plaster of paris molds for the formation of the mold cavity is not adaptable to the process using lost wax patterns. Another method has been developed for this process. A light shell a quarter to $\frac{3}{8}$ -in. thick is built up on the wax pattern by a process of dipping into a slurry and stuccoing with a glass grain. This usually involves five or six cycles to build up the wall to the proper thickness.

Two slurries are used designated as A-10 and A-O. These have the following compositions:

	A-10	A-O
"Glascast" Powder, gms.	4540	4420
Ball Clay, gms.	—	113
Aerosol OT 75%, cc	1.25	4.5
Tartaric Acid, gms.	—	42.5
"Methocel" (1.5% sol.)* cc	25	—
Gum arabic (10% sol.), cc	—	681
"Nalcoag" 35%, cc	112.5	228
Water, cc	1010	432

The A-10 slip is a heavy, slow drying mix used only for the first dip coat while the A-O mix is lighter, faster drying used for all additional coats.

The aerosol OT is added to promote the wetting properties of the slip.

"Methocel" (Technical grade 4000CPS)* is added to obtain higher viscosity with a lower ratio of solids. It contributes hardness and toughness and bond in the green state.

"Nalcoag" 35 per cent serves as a binder and adds to the hardness of the coating.

Gum arabic is added to provide high green strength in the prime coat composition and acts as a suspending agent.

Ball clay is added to thicken slips, promote suspension and improve flow properties. Its prime function is to raise the yield point of the slip in that it is flocculated by the tartaric acid addition.

The mold is built up by dipping the wax pattern in the A-10 slip, stuccoing it with "glascast" grain and allowing it to dry for about one hr. The mold is then dipped in A-O slip, stuccoed and dried. After five coats the mold is dried overnight.

The mold thus formed is fired by placing it directly into a furnace at 900 to 1000 C (1652 to 1832 F). The wax rapidly burns out and after a period of 15 to 20 min all residue carbon is burned out and the mold is ready for casting.

Because of the extremely low and uniform expansion of the silica glass aggregate as well as the low mass and thin walls involved claims indicate good dimensional control.

LOW TEMPERATURE MOLD MATERIALS

Plaster of Paris

The material of greatest importance in the manufacture of molds for the low temperature metals is gypsum or "plaster of paris."

When plaster of paris ($\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$) is gaged with water the following characteristics are observed:⁴

- 1) A setting or initial stiffening of the paste occurs about 20 min after mixing. During the time preceding this stiffening, little temperature rise occurs.
- 2) Shortly after the initial set, pronounced temperature rise and measurable expansion occur, which reach a maximum 20-30 min later.

The setting time of plaster of paris may be controlled by additives such as cations of Al^{+3} , Mg^{+2} or terra alba, all of which accelerate the set. During the setting process the hemi-hydrate reacts with water to form the di-hydrate.



For precision casting purposes gypsum is seldom used alone. Other materials are added for several reasons—1) to increase thermal conductivity (SiO_2), 2) to improve strength and cracking tendencies (asbestos, glass fibers and talc), 3) to improve permeable (inert materials, foaming agents) and 4) to overcome shrinkage of plaster when heated.

The major problem involved in using plaster is permeability. Plaster molds are dense and impervious unless special treatment of some type is resorted to. There are two main methods used to improve permeability of the plaster itself. These are autoclave treatment and foaming agents.

AUTOCLAVE TREATMENT

In the autoclave treatment when the set gypsum molds containing $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ are heated in a saturated water atmosphere at a temperature above 96 C (173 F), the reaction $2\text{CaSO}_4 \cdot 2\text{H}_2\text{O} \rightarrow 2\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O} + 3\text{H}_2\text{O}$ will proceed, since above this temperature the dihydrate is the unstable phase as shown in Fig. 13.

As autoclaving continues above atmospheric pressures this reaction continues, the water released by the reaction remaining in the mold which at this point is soft. This water being released becomes saturated with respect to CaSO_4 , the smaller crystals being dissolved as more water becomes available. Since the solubility of the hemihydrate decreases with increasing temperature, it is not desirable to autoclave at high pressures, the usual pressures recommended are in the 10-30 lb/in.² range.

After the autoclave treatment the cores are cooled preferably in a moist atmosphere. At the surface, which cools below 96 C (173 F) first and more rapidly than the interior, fine crystals of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ are precipitated. In the interior which cools slowly, larger crystals of the dihydrate grow. A core is thus produced having a smooth, fine grained surface with a porous interior. The chemical form of the material after this treatment is still the dihydrate. The only result of the autoclave treatment has been a redistribution of crystal size on the exterior and interior in order to produce a greater permeability in the core.

*Sources of materials mentioned herein may be obtained from the author.

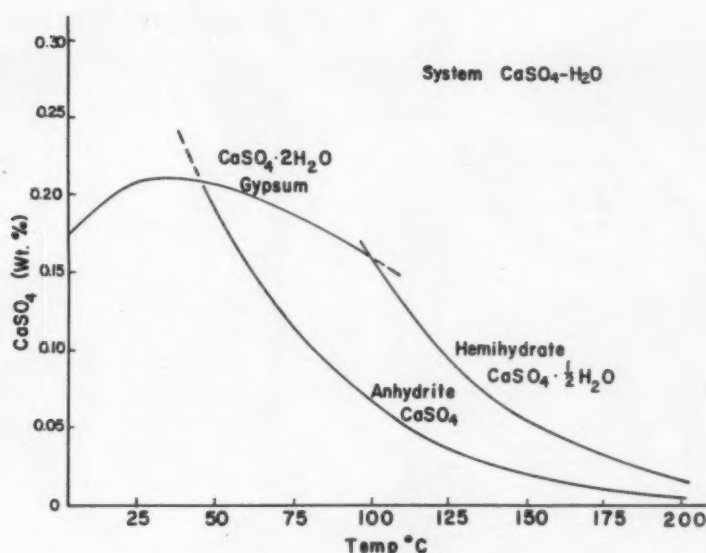


Fig. 13 — $\text{CaSO}_4\text{--H}_2\text{O}$ system.

FOAMING AGENTS

Another method of imparting the necessary permeability to plaster molds is the foam method employed by the U.S. Gypsum "hydroperm" process. This method involves the incorporation of a foaming agent with the plaster. This results in a thin skin on the mold surface behind which is a bubble structure. This results in a high permeability without the autoclave treatment.

DEHYDRATION

Since it is impossible to pour metal against such a hydrated mineral due to its release of water and resulting disastrous effects, it is necessary to dehydrate the core by heating.

The thermal analysis of gypsum in air is shown in Fig. 14.⁵ The temperature of the endothermic peak caused by the loss of $1\frac{1}{2}$ molecules of water from the gypsum is 180°C (365°F). The endothermic peak caused by the remaining $\frac{1}{2}$ molecule of water is 215°C (420°F). The small exothermic peak in the thermogram at 360°C (680°F) is caused by a change from soluble anhydrite (gamma CaSO_4) to anhydrite (beta CaSO_4) as determined by x-ray analysis of samples heated to a temperature just below and above the peak temperature.

Beta CaSO_4 changes to alpha CaSO_4 at 1225°C (2228°F) as evidenced by the endothermic peak. During this inversion a small amount of SO_3 gas is released from the anhydrite, as determined by furnace gas analysis. The endothermic peak caused by the melting of the eutectic composition is at 1385°C (2525°F).

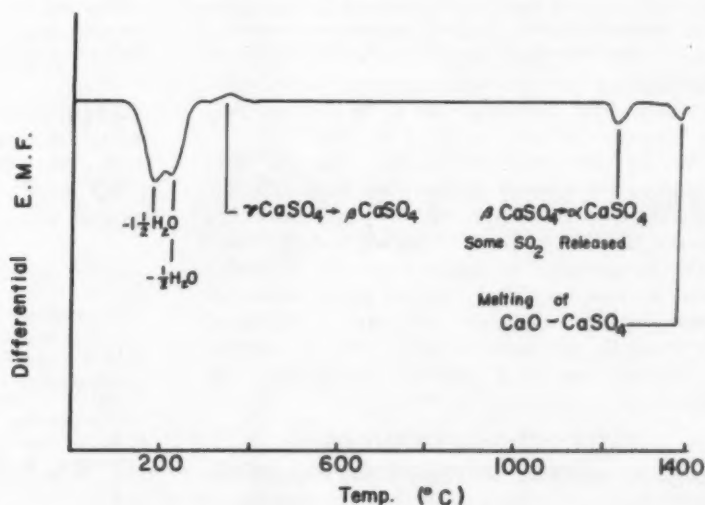


Fig. 14 — Differential thermal analysis of gypsum in air.

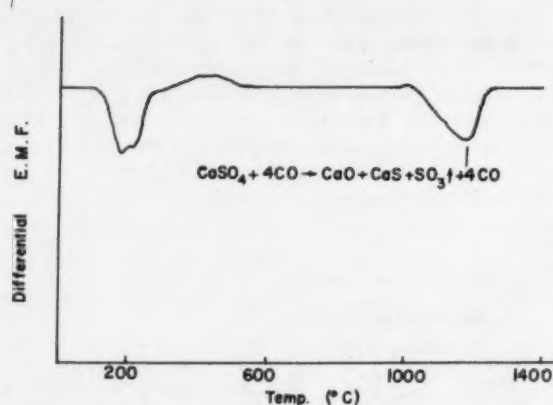
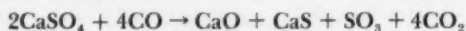


Fig. 15—Differential thermal analysis of gypsum in CO atmosphere.

The thermogram for gypsum in CO₂ and N₂ atmospheres is essentially the same as in air.

Heating gypsum in CO results in an entirely different type of behavior as shown in Fig. 15.

The exothermic peak caused by the inversion of gamma to beta anhydrite is superimposed on another broad exothermic peak probably caused by the reaction of water from the dehydration of the gypsum with carbon monoxide. A large endothermic peak beginning at 910°C (1670°F) is identified as the result of the reaction



No CaSO₄ was present above this temperature but was completely decomposed to CaO and CaS.

Carbon Monoxide Effect

There is no doubt that CO present in a mold cavity will lower the decomposition temperature of calcium sulfate. Under ideal conditions such molds may be used at temperatures below 1225°C (2228°F).

Providing the permeability of the mold is sufficiently high it is necessary to remove only 1½ molecules of water from the gypsum and certain claims are made that the remaining ½ molecule of water is advantageous since it chills the metal faster. This is no doubt true providing the gases released may escape through the mold and not the metal.

Because of this possibility of gas formation from incompletely dehydrated gypsum or from the decomposition of the calcium sulfate itself great care is taken to provide proper venting for plaster molds. In many instances it is standard practice to apply vacuum to cope and drag molds, which assists in the escape of released gases and permits the metal to lay close to the mold surface. This is particularly necessary on large castings having close dimensional and surface requirements.

DIMENSIONAL CHANGES

As with all materials the dimensional changes taking place in plaster investments depend entirely on

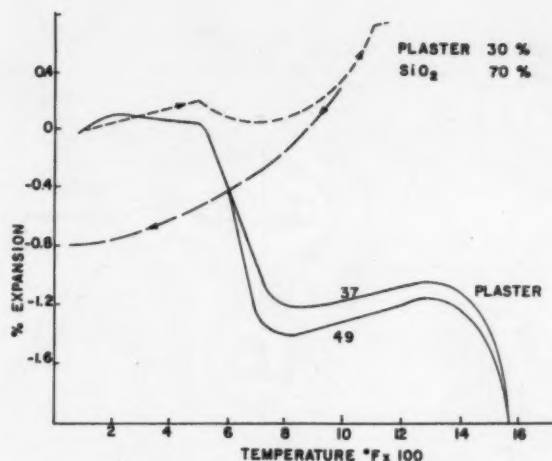


Fig. 16—Dimensional changes in gypsum-silica mixtures and gypsum on heating.

such variables as type of aggregate, per cent bond, water content and temperature of dehydration. Because of the extreme variability of these factors data are of little value.

Figure 16 shows the dimensional change taking place in gypsum as it is heated. The effect of water content of the starting mix is shown for 49 and 37 consistency. The effect of 70 per cent SiO₂ on the linear expansion is also shown, the resulting curve having little resemblance to that of 100 per cent gypsum. If one considers other common additions such as talc, glass fibers, foaming agents or asbestos there is little doubt that the thermal expansion curve would vary for each composition. This would have to be determined for each mix. As long as it is reproducible the casting manufacturer can provide for it in the original patterns.

SUMMARY

The various types of inorganic binders are discussed with particular emphasis on their chemical formation and high temperature properties.

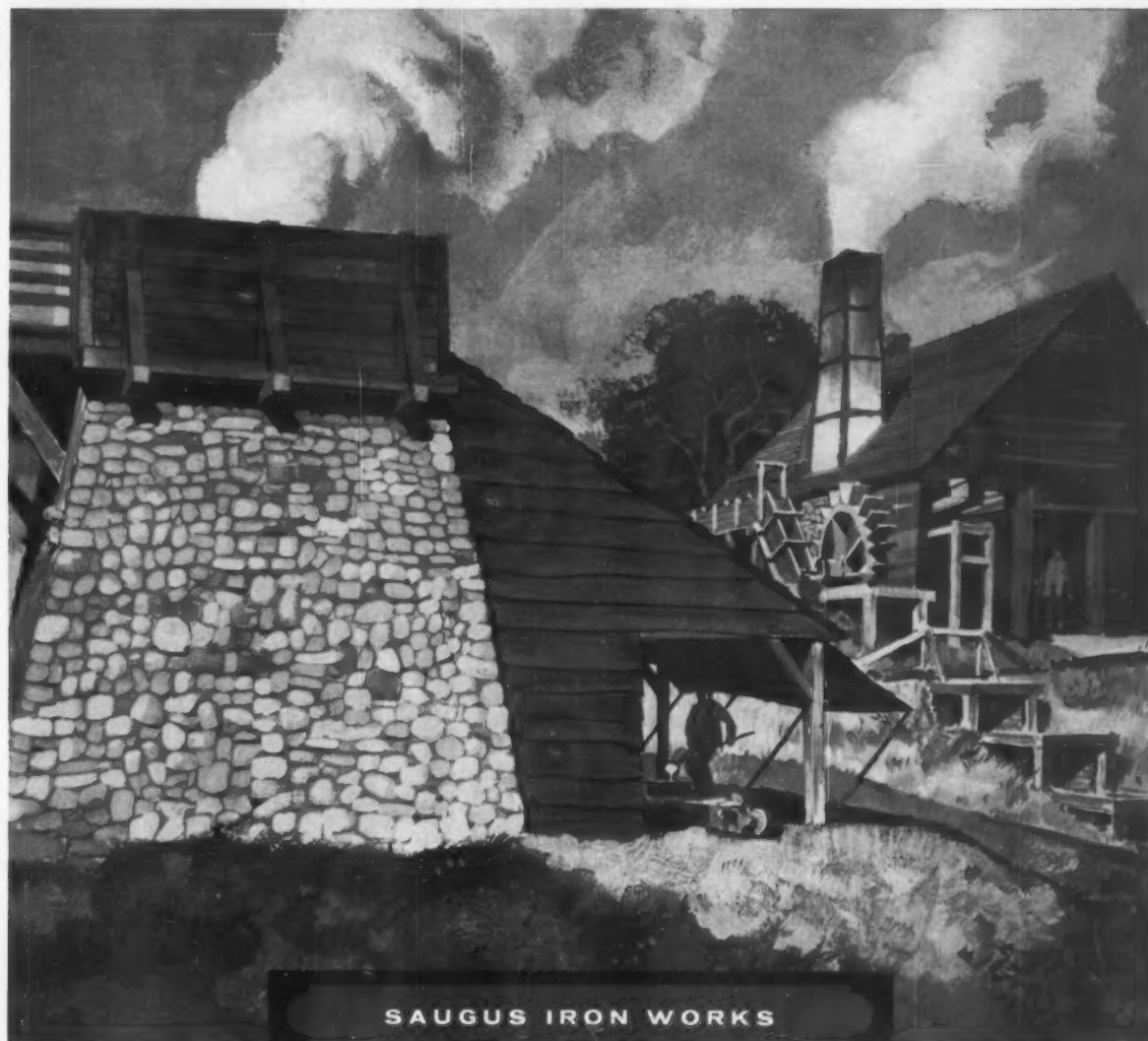
Differential thermal analysis is a valuable tool for determining the baking temperature required to eliminate gaseous products from refractory compositions.

The dimensional stability of a mold is determined largely by the characteristics of the aggregate used with some contribution from the binder which depends on the percentage of bond and liquid in the original mix.

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Gray Iron Foundry Milestones—No. 4



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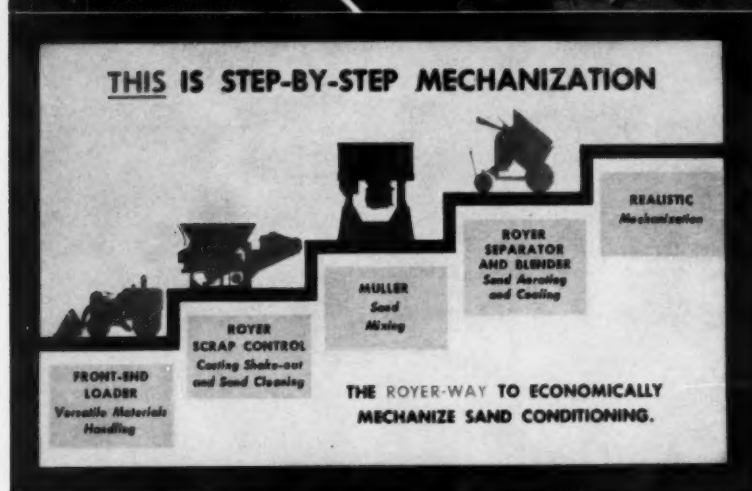
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Circle No. 159, Page 151

NEWS and VIEWS

Zurich Holds International Congress
AFS Expands Technical Assistance
T&RI Aids Chapters With Courses

Chapter Officers Optimistic About 1961; Group Sees Expansion Despite Heavy Competition

The gigantic metalcasting industry is going through a technological revolution—and the outcome is not clear. Changes in products and processes, competition, and current economic conditions are altering management thinking. Foundry production practices are being adjusted to ever-shifting market situations. Competition within and without the industry is stiff.

This is the consensus emerging from a recent grass-roots survey made among Society "influentials."

The place: the Annual Chapter Officers Conference at AFS Headquarters, which was held June 16-17.

The means: an electronic device which registers cumulatively the vote of each group participating.

Almost 100 key chapter officers and AFS leaders were polled secretly concerning industry trends, market development, current buying practices, and MODERN CASTINGS.

Trends

How's business? Almost 55 per cent expect business to be fair for the remainder of the year. Some 20.9 per cent estimate that it will be good. Nine-plus per cent declare "poor," and almost 15 per cent don't know.

The "influentials" are more optimistic about 1961; 26.7 per cent believing that it will be good. More than 47 per cent hold to the "fair" guesstimate, while about 8 per cent look on the gloomy side.

Reports on company expansion, past and future, reveal that apparently the foundry business is not as static as some would believe.

—More than 73 per cent report their foundries expanded capacity in the last five years.

—53.5 per cent report their foundries plan to expand capacity in the next five years.

Competition was rugged in the last 12 months. Almost 42 per cent said that their foundries had lost business to other methods of metal fabrication. But more than 46 per

cent declared that their foundries had taken business away from other such methods.

Buying Power

Significantly, 82 per cent of foundrymen among the Chapter Officers report they have a voice in the purchase of foundry equipment. This is indicative not only of the type of individuals belonging to AFS but also of the "team" influence in making decisions to purchase supplies and equipment.

More than 68 per cent report that their companies intend to buy foundry equipment in the next year. Of those responding favorably:

- 39.1 per cent, melting equipment.
- 71.7 per cent, molding equipment.
- 58.6 per cent, materials handling equipment.
- 53.0 per cent, cleaning room equipment.
- 23.2 per cent for inspection equipment.

—34.5 per cent for laboratory equipment.

Although this "influential" group was small in number, the results were indicative of a trend, as further questions revealed. More than 62.6 per cent report plans to modernize parts of their foundries in the next five years; 68.6 said that parts of their foundries were modernized in the last five years.

Modern Castings

Indications are that MODERN CASTINGS is much in demand at the plants of AFS "influentials." Some 54.6 per cent report that other people in the foundry business read their copy of the magazine. This broke down as follows. Of those answering:

- 17 per cent, one other person.
- 29.7 per cent, two other persons.
- 23.3 per cent, three others.
- 15 per cent, four other persons.
- 15 per cent, five or more.

Home delivery of the magazine is popular, although preferences on this count are not markedly strong.



Representing Canadian and Mexican foundrymen were: Maynard Bleaken and S. E. Robinson of the Ontario Chapter; F. I. Trevino of the Mexico Chapter; Leo Myrand of the Eastern Canada Chapter; and J. F. Prior and Henry Brumley of the British Columbia Chapter.

Chapter Officers Attend Two-Day Session to Learn Goals, Services

Chapter officers from each of the 47 chapters in the United States, Canada, and Mexico, participated in an intensive two-day briefing session, June 16-17, on Society goals and services.

More than 100 officers attended the AFS Headquarters in Des Plaines, Ill., during the morning and afternoon of June 16 and returned to the LaSalle Hotel, Chicago, dinner.

Four one-hour workshops were held at the Headquarters. They were devoted to technical developments, MODERN CASTINGS, educational activities, and membership and other chapter problems. Officers were divided into four groups, rotating between the workshops.

Each workshop consisted of an outline of department functions, long-range goals, how to improve services between chapters and the Headquarters, and between chapters and members. Following the presentations, sessions were opened to a question and answer period.

In the MODERN CASTINGS workshop, officers were addressed by Managing Director H. E. Green and Editor J. H. Schaum. Green explained the magazine's role as a publication, a Society service, and a symbol of industry leadership. He also outlined MODERN CASTINGS goals and how it hopes to achieve them.

Schaum emphasized the importance of chapter officers in encouraging participation of chapters in reporting their varied activities. He cited outstanding efforts such as technical paper writing contests and education programs.

A poll was taken of opinions on market developments, trends, buying policy, and MODERN CASTINGS. See page 77 for answers of chapter officers to these vital questions.

AFS Technical Director S. C. Masari conducted sessions on the technical program. He defined the basic purpose of AFS as the accumulation of technical information of interest to the foundry industry. It is disseminated through technical divisions and committees, research, the educational program, publications, annual convention, regional conferences, the AFS library, replies to technical inquiries, and cooperation with other technical societies and the armed forces.

Educational activities and the

Training & Research Institute were covered by AFS Education Director R. E. Betterley, who emphasized the importance of local educational programs. He also told how chapters are able to sponsor AFS-T&RI courses through the cooperation of the Training & Research Institute.

AFS General Manager Wm. W. Maloney and Secretary A. B. Sinnett discussed membership and various chapter problems and told of the services available at the National Headquarters to the local groups.

New national directors who attended the sessions at Des Plaines with the chapter officers were: Arthur E. Falk, Centrifugal Castings Co., Long Beach, Calif.; James E. Moore, Wells Mfg. Co., Skokie, Ill.; and Donald E. Webster, American Laundry Machine Co., Rochester, N. Y.

AFS President N. J. Dunbeck, International Minerals & Chemical Corp., Skokie, Ill., and National Director Clyde A. Sanders, American Colloid Co., Skokie, Ill., also attended the workshop sessions.

The second day of the conference started promptly after a buffet breakfast at the LaSalle Hotel. A four-man panel gave their firsthand expe-

riences with developing successful chapter programs. Panelists were F. A. Dun—Canton Chapter, Norman Stickney—Northeastern Ohio Chapter, Maynard Bleaken—Ontario Chapter, and Harry Blumenthal—Twin City Chapter.

The Canton Chapter has had unusually good success with plant visits in the evening. Foundry visit usually includes dinner and a talk describing the facilities. Considerable discussion revolved around varying degrees of success and failure with joint meetings between AFS chapters and local chapters of other technical societies.

Next on the agenda was an explanation by W. W. Maloney of the new AFS exhibit frequency. Unlimited exhibits are scheduled for San Francisco in 1961, Detroit in 1962, Atlantic City in 1964 and Cleveland in 1965. There will be no exhibit at the 1963 Congress in St. Louis nor at the 1966 meeting. Considerable effort is being expended in the direction of improving relations between exhibit hall services and exhibitors.

N. J. Dunbeck explained the coming schedule of regional administrative meetings and A. B. Sinnett discussed "Planning a Regional Foundry Conference." The national office is ready to assist conference committees with programs and publicity. Planning should start nine to twelve months ahead of the actual date of the conference.

A second panel of four men relat-



Conference gave officers a chance to get acquainted with foundrymen from other sections of the United States, Canada, and Mexico. Many common problems were discussed at informal meetings such as this. Shown are John F. Prior and Henry Bromley of the British Columbia Chapter and Jarl A. Haynen of the Central Ohio Chapter. Panel discussions were also held to have various chapters explain how they were successful in solving such problems as membership, program planning, and educational activities.

ed their techniques for success in gaining new members for their chapters. On the panel were Harry Ferlin—Tri-State Chapter, Robert Hunter—Metropolitan Chapter, Ron Turner—Western New York Chapter, and Bradley Booth—Wisconsin Chapter. Particular emphasis was placed on the importance of impressing top management with the values accruing to foundry employees through AFS membership and participation. Some membership chairmen are able to recruit new members by making personal visits to foundries. Others use the phone, letters, and fellow members to stimulate interest in their chapters.

Eighteen chapters were presented certificates signifying they achieved their membership goals during the past year.

W. W. Maloney presented a simplified explanation of where the AFS income comes from and where the dollars are spent. C. G. Fuller related the successful acceptance and achievements of the first AFS BUYERS DIRECTORY.

H. J. Weber concluded the program with some startling statements of money and lives that have been saved through the AFS Safety, Hygiene & Air Pollution program. For the first time now the personal services of Weber are available to AFS Chapters and foundries if they need any technical assistance in the scope covered by SH&AP.



Due to inclement weather, lunch was served indoors. Photo shows a portion of the AFS library.



Discussing AFS problems during a break are: Howard Bodwell of the Eastern New York Chapter, AFS President N. J. Dunbeck, and Bradley Booth of the Wisconsin Chapter.



Chapter problems, large and small, are discussed at the June Chapter Officers Conference by Rochester Vice-Chairman L. H. Calahan and Mo-Kan Chairman H. L. Mead.



AFS Educational Director R. E. Betterley explains operations of the Training & Research program which has conducted classes in the United States and Canada.

Technical Council Develops Plans for Future Investigations of Basic Problems

The annual Technical Council meeting brought 22 prominent industry leaders to Chicago to report on the past years' successful program and to launch an ambitious forecast of plans for the coming year.

AFS President Norman J. Dunbeck thanked the chairmen and vice-chairmen of the divisions and general interest committees for their time and effort to advance the technology of the metalcasting industry.

Dunbeck encouraged the council members to continue their plans for further projects to be sponsored by AFS.

A tentative schedule for the 1961 Castings Congress was presented by Technical Director S. C. Massari. Certain adjustments were made to fit the special needs of the various groups.

Education Director R. E. Betterley reported on the growing support of the AFS Training & Research Institute program. More chapters are co-sponsoring courses this year than ever before.

Here are the highlights of some of the reports presented at the council meeting:

Malleable Division

Four projects are planned:

1—Evaluation of the effect of elements commonly present, sulphur, phosphorous, and magnesium on the known carbon and silicon range which will produce compact graphite as-cast.

2—Study of the effect of additions to the melt or alloying in the results in project No. 1.

3—Modification of experiments in No. 1 and 2 as indicated by fundamental solidification studies now in progress.

4—Evaluation of mass or section size effects, properties, annealability, etc., if the project of a compacted graphite as-cast malleable is obtained.

A best papers award, patterned after the Gray Iron Division award, will be presented to the author or authors at the Round Table luncheon to take into account the manner of presentation as well as the contained material.

Steel Division

The research committee has held several important meetings. Contract

work with the University of Michigan on an intensive investigation of the "ceroxide defect" represented the chief interest of the committee during the past several months.

John Rassenfoss, as chairman of the research committee, is presently directing interest of members toward careful consideration of possible topics for new studies which would be undertaken at the successful conclusion of the present program.

Brass & Bronze Division

The AFS-sponsored research at the University of Michigan has shown that a single variable, the thermal gradient during solidification, is the principal factor governing shrinkage. It should be possible to produce pressure-tight, high-density regions in any reasonable casting design with mechanical properties equal or superior to the cast tensile bar.

Light Metals Division

The research committee is planning a thorough review of the last 12 years' research conducted by AFS in the gating and feeding of light alloy castings. This information will be abstracted and presented, probably in the form of a strip film with written commentary. In addition, a review type paper suitable for use in TRANSACTIONS or other AFS publications will be prepared.

Die Casting & Permanent Mold

The 1960 Castings Congress is the third year this division has conducted its own program. Five papers were presented in 1958, six in 1959, and nine in 1960.

The Mold Process Committee was divided into a Die Casting Process Committee and a Permanent Mold Process Committee. One of the functions of the latter group is to bring up to date the permanent mold bibliography. Both groups will cooperate with the various casting design committees to work on the new handbook.

Education Division

The publications committee has rewritten the booklet "Your Future in the Foundry," used by vocational school students, career carnivals, and parent teacher organizations.

Thirty-six students attended the 1960 Convention under a program



General Manager W. W. Maloney, President Dunbeck and former President Durdin hold talk.



Pattern Division Chairman J. M. Kreiner and Vice-Chairman R. L. Olson have conference with Modern Castings Editor J. H. Schaum.



New Technical Council Chairman H. J. Rowe, J. G. Mezoff and A. J. Kiesler have a chat.



Nick Sheptak and Technical Director talk about future plans.



Technical Council members relax during annual conference.

initiated by the division's Students to Convention Committee. Seven chapters participated in the program by sponsoring the students.

Sixty showings or bookings of the film, "Cast Metals and You," have been made since it was completed in Oct. 1959 under the guidance of the division. To meet the demand, additional copies of the film have been purchased.

A total of 461 students from 182 companies participated in the annual Robert E. Kennedy Memorial Apprentice Contest.

SH&AP Committee

The general goal of the various AFS Safety, Hygiene & Air Pollution Committee is to make possible the continued progress of the foundry industry as a good place to work. The most recent achievement toward this goal was the publication of the **FOUNDRY RADIATION PROTECTION**

MANUAL, developed by the Radiation Protection Committee.

In view of an increasing interest in the subject of water pollution control, the AFS Water Pollution Committee is now in the process of being organized. The increasing application of wet-type air pollution control equipment indicates the need for a better understanding of associated water pollution control problems.

Heat Transfer Committee

Three projects were under consideration. First, a bibliography on heat transfer in the foundry; this should be ready within the next year. Second, a proposed movie of heat transfer fundamentals. Third, the question of heat loss or temperature drop in metal flowing in a gate. This is the first kinetic study undertaken by the committee and will eventually lead to a study of heat losses as the mold fills. Some 65 runs on chan-

nels of various sizes have been made using the thermocouple measurements to determine the heat drop. The committee now has the data on aluminum, which will serve as a reference point for computer work.

Industrial Engineering

The objective is to provide a coordinating body, within AFS, in order to assess, summarize, and publish information on new or modified industrial engineering techniques and cost control procedures.

Included are the usual industrial engineering functions such as time study, wage incentives, material handling, process development, methods, estimating, pricing, payroll, budgetary control, accounting, etc.

In the future, it is planned to have the casting estimate and pricing survey lead into a seminar to be held in conjunction with the technical session at the 1961 Convention.

1960 EDUCATIONAL COURSES

AUG.—SEPT.

Subject and Description	Dates	Where Given	Course Fee
Blue Print Reading, Estimating Basic fundamentals and principles necessary when considering new jobs. Job analysis techniques are presented in logical step-by-step procedure . . . including the initial reading of blueprints to production planning. Practical methods of estimating new jobs are studied, emphasizing "danger points" which can increase production costs. This course covers information which is vitally important for economically successful foundry operations. Key personnel involved in these responsibilities can learn new techniques. Course No. 8	Aug. 17-19	Chicago	\$60
Core Practices Concentrated core instruction for foremen, sales engineers, supervisors, technicians, engineers, and management. All aspects of materials, mixing, sand testing, economical application, advantages and limitations of new processes and materials are studied. Casting losses attributed to cores are analyzed for solutions. Case problems are welcomed for class discussion. Course No. 10.	Aug. 29-Sept 2	Chicago	\$90
Foundry Refractories Intensive specialized instructive course, providing informative, up-to-date- technology on foundry refractories. Emphasis on types, selection, use, maintenance and economy in foundry practices. Course provides broad understanding of expendable foundry materials and how the intelligent use can reduce operating costs. Course designed for supervisors, foremen, technicians, engineers and management. Course No. 11.	Sept. 12-14	Chicago	\$60
Economical Purchasing of Foundry Materials Course gives detailed instruction on intelligent buying of scrap, refractories, sand, alloys, binders, core oil, additives, etc. Includes up-to-date information on all aspects of foundry materials purchasing. Valuable to supervisors, engineers, purchasing agents, foremen, and management. Course No. 12.	Sept. 26-28	Chicago	\$60

REGISTRATION: Make reservations for all 1960 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received at AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill.

T&RI Services Permit Courses by Local Chapters

Presentation of technical courses on a local level has been greatly eased for chapters through services of the AFS Training & Research Institute. During the past two years, six chapters have presented a total of ten courses. Others are encouraged by AFS-T&RI Director S. C. Massari to investigate the possibility of their participation.

Five points of responsibility are assigned to chapters:

Name and type of course to be held.

Length of course.

Where and when course is to be given.

Willingness to adequately support the course.

Appoint a local liaison officer for chapter contact.

Chapters are largely responsible for local support such as adequately publicizing the course at local chapter meetings, a mailing to its membership, and the development of a sizable registration from the local chapter area.

T&RI will completely handle all course details as to instructors, hotel facilities, instructional materials, meal functions, and promotional literature.

Fees are based upon the length and type of course—whether lecture or laboratory. Following are the charges.

Length of Course	Lecture Course	Laboratory Course
One Day	\$30	\$50
Two Days	\$45	\$75
Three Days	\$60	\$100
Five Days	\$90	\$150

Typical regional courses for chapter participation include Cupola Melting of Iron, Gating & Riserling, Gray Iron Metallurgy, Ferrous Metallurgy, Non-Ferrous Metallurgy, Sand Control & Technology, Preventive Maintenance, Melting of Light & Copper-Base Alloys, Shell Molds and Cores, Core Practices and Ductile Iron Production. Other courses may be suggested by the chapter and considered by T&RI.

Chapters are urged to make their intentions known by Oct. 1 so that the course can be included in the next year's brochure.

All inquiries for additional information should be directed to the AFS-Training & Research Institute located at Golf & Wolf Roads, Des Plaines, Ill.



Members of the Sand Division Executive and Program & Papers Committees meeting during June in Chicago to map future plans for the division. These include the sponsoring of two sand shop courses to be held at the 1961 Castings Congress to be held in San Francisco. The two shop courses will be of a practical nature, rather than highly technical, to suit the needs of small foundry operators. The theme will be the value of laboratory tests for green sand properties to foundry operations.



Ductile Iron Executive and Program & Papers Committees held a combined meeting during June in Chicago. Shown are: K. D. Millis, International Nickel Co.; A. H. Rauch, Deere & Co.; Eric Welander, John Deere Malleable Works; H. W. Ruf, Grede Foundries, Inc. Also S. C. Massari, AFS Technical Director; David Matter, Ohio Ferro Alloys Corp.; A. W. Anderson, International Harvester Co.; W. D. McMillan, retired; George Krumlauf, Republic Steel Corp.; S. S. Phillips, Ohio Ferro Alloys Corp.



Malleable Molding Materials & Methods Committee meeting in Chicago during May, left to right: R. W. Heine, University of Wisconsin; A. H. Zrimsek, Magnet Cove Barium Corp., Arlington Heights, Ill.; S. C. Massari, AFS Technical Director; L. W. Lesperance, Belle City Malleable Iron Co., Racine, Wis.; R. R. Schaaf, National Malleable & Steel Castings Co., Cleveland.



Basic Concepts Committee of the Sand Division meeting discusses sieve tests at its last meeting. The committee is currently investigating the behavior of sand. Work is currently being done at Penn State using glass beads for study purposes. Preliminary tests indicate that packing by vibration does not result in rhombic packing due to segregation of fines if no bond is present.

Society Expands Technical Help

Expanded technical services in the fields of safety, hygiene, and air pollution are now available to chapters at no charge and to individual foundries—particularly sustaining and company members—at transportation and travel expenses only.

These services have been available but on a comparatively limited basis.

Herbert J. Weber, Director of the Safety, Hygiene, and Air Pollution Control Program will visit chapters and plants to consult on air pollution legislation, dust control, ventilation, foundry heating, dust control, occupational disease investigations, radiant heat, radiation from x-ray or radioisotope, safety, and plant layout involving these areas.

Considerable savings are possible in this highly specialized field, not only in existing foundries, but also in new plant construction, modernization, and expansion.

To obtain this service, requests should be written to AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill. Requests will be answered on a first-come, first-serve basis.

Ductile Experts Study Problems

What is your ductile iron problem? Foundrymen attending the AFS Training & Research Institute course on *Production of Ductile Iron* had aspects of their problems discussed by a panel of experts.

Actual case histories were submitted to the panel as part of the course held June 27-29 at the Bismark Hotel in Chicago. The course examined various phases of ductile iron from melting to heat treating with instruction provided by industry authorities.

Subjects given detailed study were melting equipment and practice, production of the base iron, melting units, desulphurization and carburization, applications and uses, nodulizing alloys, inoculation, determination of ductile iron, metallurgy, and gating and risering.

Instructors were: Eric Welander, John Deere Malleable Works, East Moline, Ill.; Vernon H. Patterson, Vanadium Corp. of America, Chicago; Harold W. Ruf, Grede Foundries, Inc., Milwaukee; A. H. Rauch, Deere & Co., Moline, Ill.; and H. O. Meriwether, Lynchburg Foundry Co., Lynchburg, Va.

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Blast cleaning is admittedly a job of many variables, hard to keep on an even keel. Involved in economical blast cleaning are such things as good housekeeping, good control over equipment and, of course, good shot and grit. Many blast cleaning troubles develop, because the characteristics of many abrasives vary with each shipment!

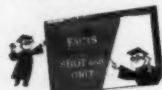
NATIONAL has developed its ability to give you abrasives with controlled characteristics ton after ton after ton. This eliminates the *one* variable over which you have no control and makes possible staggering savings. Cost-conscious customers have enjoyed this NATIONAL advantage for over a decade!

Exactly what is **YOUR** application? Are you using steel? **PERMABRASIVE®** can save money through faster cleaning and lower costs per ton. Are you using an ordinary annealed abrasive? **PERMABRASIVE®** can save money through faster cleaning, minimum graphitic carbon content, and longer life, because of

a low phosphorus content. Are you using chilled? **CONTROLLED "T"®** can save money up to 50% on consumption and up to 40% on maintenance costs, because of its controlled BHN: an iron fist (for the product to be cleaned) in a velvet glove (to be kind to blast cleaning machinery). Have you a tough, individual problem? **NATIONAL'S** metallurgists **KNOW** what it takes to reach an objective and **KNOW** how to produce a custom-made abrasive for a specific job!

We're not just talking to hear our own voices. Everything can be proven to you in your own plant under your own conditions as it has in thousands of other cases—without an operation-disturbing test. Try us!

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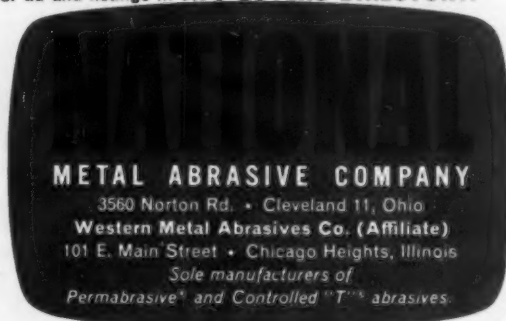
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Green Sand Committee Seeks Data at Operational Level

Green sand properties of sand offer a never-ending opportunity for further study. The Green Sand Properties Committee of the Sand Division decided to make a thorough study of sand properties based on new methods of evaluation. This same committee has just finished a complete rewriting of their portion of the SAND HANDBOOK.

In recent years, numerous authors have pointed out the importance of mold hardness as related to castings. A review of the foundry literature shows that no one report discusses all factors involved. Nor are there many reports that emphasize how mold hardness changes sand properties.

The committee decided to investigate casting quality, dimensional control, and sand properties as affected by mold hardness. This is a formidable undertaking. It involves synthetic and natural sand, southern and western bentonite, fireclay, carbon and non-carbon additives, cellulose and cereal, steel, gray iron, malleable, aluminum, and the brasses.

Each of these may present a different type problem, particularly when coupled with the large number of available sand testing procedures.

A working committee meeting was held May 23-24 in the foundry laboratories of Hill & Griffith Co., Cincinnati. Pictures on this page were taken at the meeting.

Aluminum was chosen as a starting point for this investigation using a synthetic sand formulation consisting of sand, southern bentonite, and water.

To make the test practical, a foundry sand was picked from a shop using the same base sand in daily use and producing good castings. This gave a theoretical and practical evaluation simultaneously.

During the tests moisture and mold hardness were varied. Held constant were sand mulling procedure, a pattern, metal temperature and analysis, pouring, shakeout, and cleaning procedure. The sand properties were studied with both old laboratory equipment and the latest available.

Committee members were assigned to teams responsible for each phase of the testing work. All groups worked out detailed procedures so that duplicate results could be pro-

duced. A large number of castings were produced and evaluated. In addition, all data collected was given to the statistical committee for further study.

The committee hopes to produce an operator's handbook that will show in graphic, tabular, and written form, information useful in daily operations. Much information produced in the past has been based on procedures and formulations not applicable to daily operations. The information has had only a theoretical value.

by J. S. SCHUMACHER,
Committee Chairman,
Hill & Griffith Co.

All photos by Joe Schumacher, Jr.



Casting measuring is done by Don Dietzler, Hill & Griffith Co., with recording performed by Joseph Leaverton, Hamilton Foundry, Inc., Hamilton, Ohio.



Another checking team is composed of Maurice Bollinger, William Powell Co., Cincinnati, and Ralph Steinmuller, Harry W. Dietert Co., Detroit.



Molding operations are performed by W. M. Ball, Hill & Griffith Co., Cincinnati, and Robert Ritter, also of Hill & Griffith.



Mold hardness testing is performed by J. D. Voss, Hamilton Foundry Co., Hamilton, Ohio, and Sand Division chairman Victor M. Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland.



Outlining of project is done by Prof. Roy Swift, University of Kentucky, Lexington, Ky.; committee chairman Joe Schumacher, Hill & Griffith Co., and Ralph Anderson, Engineering Casting Co., Marshall, Mich.

The committee hopes to extend the prior work into the realm of how to make better castings through the use of facts and figures. It is planned that an initial publication of the results be compiled by next year.

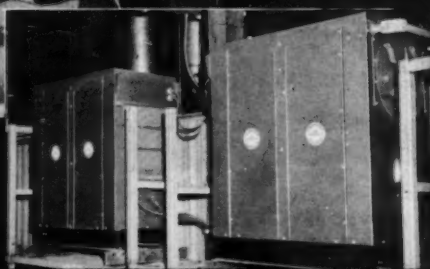
Foundries Find

miller-powered carbon arc cutting

Faster — Cheaper — Better



These photos, taken in well-known foundry, show operator carbon-arc cleaning a casting using an Arcair torch powered by a Miller SR-1000-A7. Note handiness of control console.



Battery of Miller SR-1000-A7's is located well away from cleaning room.

THE MILLER MODEL SR-1000 series, providing 1000 amperes of d-c at 40 arc volts, 100% duty cycle, has proved to be the ideal power source for Arcair and other foundry carbon arc cutting processes. Designed and built around Miller's exclusive semi-metallic, completely sealed Gold Star rectifier, drastic overloads are handled routinely without failure or deterioration. Control console is instantly removable to any reasonable distance. Adjustment of current range from 200 to 1400 amperes is accomplished under load. What's more, the operator can switch in a flash from cleaning and gouging to welding when needed. Operates from three phase power lines.

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Attention Focuses on Zurich for International Congress

Twenty-four official exchange papers from 18 countries will be presented at the 27th International Foundry Congress to be held Sept. 19-24 in Zurich, Switzerland.

Papers are divided into three classifications; new research in foundry technology, modern processing in foundries, and man and the foundry.

The American exchange paper is "Grain Refinement of Cast Metals," by J. F. Wallace, E. W. Form, G. Gould, G. K. Turnbull, and H. Merchant of Case Institute of Technology, Cleveland.

Other papers are:

New Foundry Research

"Studies in Cementite Decomposition"—R. Mitsche (Austria).

"Some Results in Investigations of an M.B.C."—R. Doat, H. Dautreloux, and H. De Rijcker (Belgium).

"Some Investigations on Properties of Mold Materials at High Temperatures"—Ove Hoff, F. Hauser, and Overgaard-Rasmussen (Denmark).

"Behavior of Hydrogen in Cast Steel"—P. Bastien (France).

"Time Course of Cooling-off, Hardening and Transmutation in Castings"—W. Patterson and W. Koppe (Germany).

"Anisotropic and Mechanical Behavior of Gray Cast Iron"—J. S. Abcouwer (Holland).

"Experiments and Results with Light-Metal Castings in Aluminum Ingot Molds"—K. Marechal (Hungary).

"Graphite Formation in Cast Iron"—A. G. Minkoff (Israel).

"Influence of Super-Cooling upon the Fluidity of Molten Metals"—S. Morita (Japan).

"Determination of Linear Combustion Speed in the Combustion Zone of the Cupola Furnace"—C. Podrzucki (Poland).

"Influence of Increased Lead Content on Pressure Tightness of Leaded Red-Brass 85-5-5-5"—L. Ekblom (Sweden).

"The Problem of the Classification of Gray Cast Irons and the Role of the Secondary Structure"—A. Coulaud (Switzerland).

"Gases in Ferrous Alloys"—B. Marinček (Switzerland).

"Molding the Metal Flow in the Solution of Pouring Technique"—M. Bednarik (Czechoslovakia).

"A New Method for Examination for Quality Checking of Cast Iron

by Means of Ultrasonics"—A. Lehtinen (Finland).

"Mold Paints and Washes for Use in the Steel Foundry"—J. M. Middleton (Great Britain).

"Manufacture of Pearlitic Gray Iron in Electric Furnace"—N. G. Chakrabarti, U. K. Bhattacharya, B. K. Gupta, and N.R. Mitra (India).

"Determination of Foundry Costs"—E. Lotti (Italy).

"Aluminum Castings for Anodic Oxidation"—A. Bloch (Switzerland).

"The Further Development of the Bührer Molding and Casting Equipment"—W. Gotz (Switzerland).

"Electric Smelting in the Foundry"—E. Zingg (Switzerland).

"The Use of Waterglass-Bentonite Sand Mixtures without Blowing Through with CO₂"—M. B. Pajevic and J. Kruspel (Yugoslavia).

Man and the Foundry

"Labor Peace in the Swiss Machinery and Metallurgical Industry"—Dr. H. Schindler (Switzerland).

How Committees Are Progressing

Foundry investigations and planning for the annual convention are constantly being conducted by the technical divisions and general interest committees. Recent reports include:

Sand Division

PROGRAM & PAPERS COMMITTEE—Two shop courses will be presented at the 1961 Castings Congress in San Francisco. They will be designed to be practical rather than technical.

The tentative theme is "What Do Laboratory Tests for Green Sand Properties Mean to Your Foundry Operations." Ted Linabury, Miller & Co., Chicago, has been named as chairman. L. E. Taylor, Ottawa Silica Sand Co., Ottawa, Ill., and F. S. Brewster, Brumley Donaldson Co., Huntington Park, Calif., are committee members.

CONTROLLED CASTING QUALITY—Fifty-three colored slides of casting defects, submitted by the Northwestern Pennsylvania Chapter, have been reviewed.

BASIC CONCEPTS—Committee work on sieve tests has produced re-

sults falling within experimental limits. Photomicrographs showing the shape and defects in the beads indicate that they are not truly spheroidal.

Preliminary tests conducted at Pennsylvania State University using glass beads, indicate that the behavior of sand appears to be about the same as with glass beads. The next step will involve preparation of an adequate supply of each fraction and then proceed with density measurements utilizing combinations that supposedly represent geometrical grain fit.

It appears from preliminary tests that packing by vibration does not result in rhombic packing due to segregation of fines if no bond is present such as bentonite. It appears that the shape of the container may be the factor.

Photomicrographs of a series of sands of varying character, classified with a proposed test for angularity were submitted. A second series of photomicrographs, without captions, will be sent to each member for their evaluation of angularity. An analysis of the ratings will be prepared.

Ductile Iron

EXECUTIVE AND PROGRAM & PAPERS COMMITTEES—A proposed joint round table luncheon meeting sponsored by the Gray Iron, Malleable, and Ductile Iron divisions as a means of increasing attendance, is being supported by the Ductile Iron Division.

Work is also being continued establishing magnesium determination in ductile iron. Results from a number of cooperating laboratories varied widely but were reasonably consistent within a given laboratory. It is possible that results will be available for the 1961 Castings Congress.

A report on the committee's project to develop a suitable micro test bar for evaluating the character of graphite in a given melt of ductile iron was presented at the 1960 Convention.

Die Casting & Permanent Mold

EXECUTIVE AND PROGRAM & PAPERS COMMITTEE—Preliminary steps have taken on a proposed research project on metal flow and gating jointly sponsored by AFS, American Die Casting Institute, American Zinc Association and the Lead Industry Association.

The former Mold Process Committee has been reorganized into a Die Casting Process Committee and a Permanent Mold Process Committee.

"The foundrymen's answer to the aircraft industry," has been picked as the division's theme at the 1961 Castings Congress in San Francisco.

CHAPTER NEWS



ONTARIO—Chapter officials and speaker C. A. Sanders, American Colloid Co., Skokie, Ill., second from left. Others are Director M. E. Hollingshead, 1959-60 Chapter Chairman Ted Taffel, 1960-61 Chairman M. D. Bleaken, and 1959-60 Publicity Chairman V. H. Furlong.



EASTERN CANADA—Apprentice winners in the chapter's annual contest. Competition was held in iron, bronze, and steel molding, and wood patternmaking.—by Jim Cherrett



NORTHWESTERN PENNSYLVANIA—Volumes of the 1957 and 1958 *Transactions* were presented in May to the Technical Memorial High School, Erie, Pa. Shown are R. W. Griswold, Erie Malleable Iron Co.; F. E. Bahm, foundry instructor at the high school; William Wilmot, Ulrich Foundry Co., Erie, Pa.; Chapter Chairman W. E. Eccles, Cooper-Bessemer Corp., Grove City, Pa.—by Walter Napp



METROPOLITAN—Attending the April meeting were Chapter Chairman John O'Neill, Malcom Foundry Co., Newark, N. J.; 1959-60 Chairman R. B. Fischer, Ingersoll-Rand Co., Phillipsburg, N. J.; speaker Alexander Schwan, Sun Oil Co.; Ed Shaploo, New Jersey Silica Sand Co., Millville, N. J.; and Director J. J. Silk, Taylor & Co., Brooklyn, N. Y.



EASTERN CANADA—Leo Myrand, Montreal Foundry, Ltd., right, new chapter chairman, receives gavel from former chairman A. H. Lewis, Crestweld Mfg. Co.—by Jim Cherrett



EASTERN CANADA—First and second place winners in the annual technical paper contest were Michael A. Notte, Canada Steel Foundries and Max Reading, Foundry Services (Canada) Ltd. Shown are Reading, 1959-60 Chapter Chairman A. H. Lewis, and Notte.—by Jim Cherrett



CENTRAL OHIO—K. M. Smith, Caterpillar Tractor Co., Peoria, Ill., left receives congratulations on his preventive maintenance talk in April by technical chairman Harry Grable, Ohio Malleable Div., Dayton Malleable Iron Co., Columbus, Ohio.—by Joseph A. Riley, Jr.



TWIN CITY—Attending the May meeting were Frank Ryan, St. Paul Brass & Foundry Co., in coming vice-president; Harry Blumenthal, American Iron & Supply Co., Minneapolis, incoming chairman; and Carter DeLaitre, Minneapolis Electric Steel Casting Co., out-going chairman.



METROPOLITAN—Alexander Schwan, Sun Oil Co., discussing "Human Engineering—Its Relation to Foundry Personnel," at the April meeting.



TWIN CITY—Three chapter apprentice contest winners were presented with awards by Frank S. Ryan, chairman of the education committee, on right. Winners were: Philip Irishman who won sixth place national honors, Dennis Blom, James Myer.



NORTHWESTERN PENNSYLVANIA—At the speaker's table during the April meeting were Chapter Chairman W. E. Eccles, speaker C. A. Sanders, and Vice-Chairman W. J. Miller—by Walter Napp



PITTSBURGH — Congratulations are in order after a golfing round. Left to right: J. Wiefeling, United Engineering & Foundry Corp.; R. J. Vanden Heuvel, Milwaukee Chaplet & Mfg. Co.; J. Oxenreiter, United Engineering & Foundry Corp.; and chapter photographer Walter Napp, Milwaukee Chaplet & Mfg. Co.



Northwestern Pennsylvania—Resin binders were discussed at the May meeting by O. J. Myers, Reichhold Chemicals, Inc., White Plains, N.Y.—by Walter Napp



CHESAPEAKE—Digging into the crabs at the annual feast are Lou Gross, Mergenthaler Vocational High School and Jim Parker, American Radiator & Standard Sanitary Corp.—by V. R. Chastang



CENTRAL OHIO—Dallas Marsh, left, Cooper-Bessemer Corp., Mt. Vernon, Ohio, presents gift of appreciation to Dan Krause, Gray Iron Research Institute, Columbus, Ohio, for his job as chairman of the Ohio Regional Foundry Conference.—by Joseph A. Riley, Jr.

Metropolitan Chapter

Human Engineering Talk

Understanding the human machine is lacking in the average organization despite our advances in the practical technologies, Alexander Schwan, Sun Oil Co., told members at the two evening talks sponsored by the education committee.

Effective communication is achieved when management through supervisors, conveys information for the most efficient operation of the foundry. Be fair, be firm, be honest is the best principle to follow in employer-employee relationships. Every effort should be made through communications to remove fear and anxiety of the worker for a better performance. Industrial family problems are best resolved when all elements are solicited for contributions connected with a particular situation. by—J. J. Silk

Twin City Chapter Assists Apprentices in Job Hunting

Assistance for placing vocational school patternmaking graduates is being provided by the education committee of the AFS Twin City Chapter.

Letters have been sent to chapter members pointing out that a number of four-year patternmaking graduates completed their schooling in June from the Minneapolis Vocational School and St. Paul Vocational School.

Frank S. Ryan, St. Paul Brass Foundry, education committee chairman, reminds members that the era of attempting to train raw, unskilled, untrained labor to key foundry jobs should be past.

Asks Ryan, "What better source can you name for foundry technician trainees, foundry foremen trainees, and other key job trainees, than these technically trained patternmaking apprentices?"

Recommend Sponsoring of Student Tours as Local Chapter Project

Sponsoring of student tours by local chapters has been advocated as an effective education committee project. Various chapters have undertaken such programs in their area. During 1960 such an undertaking was performed on a larger basis.

Thirty-six students from seven chapter groups attended the AFS Castings Congress & Exposition through efforts of the Students for Convention Committee of the AFS Education Division.

The committee, headed by E. G. Gentry, Penola Oil Co., Detroit, encouraged chapters to sponsor students to attend the convention. Chapter cooperation included providing expenses, outlining of Casting Congress highlights, and arranging for plant visitations.

Participating chapters and the number of students sponsored were:

Pittsburgh	13
Detroit	9
Chicago	4
St. Louis	4
Central Illinois	1
Committee members responsible for	



NORTHWESTERN PENNSYLVANIA—A look toward future foundries was described at the April meeting by C. A. Sanders, American Colloid Co., Skokie, Ill.—by Walter Napp

Birmingham Chapter

Hears Sand Segregation Talk

Causes and effects of sand segregation were outlined at the April meeting by T. W. Seaton, American Silica Sand Co., Ottawa, Ill. Topics covered included the effect of segregation on the physical properties of bonded sands, recommendations on segregation control and how an understanding of segregation will assist in writing specifications for new sand purchases.

—by Edwin Phelps

contacting the participating chapters were: Robert C. Kane, Midvale Mining & Mfg. Co., St. Louis; Dallas March, Cooper-Bessemer Corp., Mt. Vernon, Ohio; A. Fred Rossomando, Sperry Gyroscope Co., Div. Sperry Rand Corp., Great Neck, N. Y.; D. F. Rundle, Chrysler Corp., Detroit; John C. Harwood, Standard Foundry Co., Racine, Wis.

Reaction of the students to the convention is typified by a letter sent to the Detroit Chapter by Gordon A. Creeger, an attending student who said:

"As a student with little previous practical foundry experience, the trip gave an excellent opportunity to correlate the principles learned in school with the applications in industry.

"I was surprised at the number of different fields connected with the foundry. I was also impressed by the cooperation between AFS and other interests in matters dealing with research. I feel that the three days spent at the convention were an important part of my education as a future metallurgist."

Eastern New York Chapter

Chemically Produced Patterns

Fundamentals of chemically produced metal patterns was explained at the April meeting by John O. Trimble, Carbonyl Metal Products Co. Div., Budd Co. Also attending the joint meeting were members of the American Society of Tool and Manufacturing Engineers, Schenectady chapter.

This process produces nickel patterns with a melting point of 2600 F., a tensile strength of 85,000-95,000 psi, and an elongation of 15 to 20 per cent. The pattern has a Brinell hardness range of 181 to 222 and will harden under impact of sand from a slinger. Masters for this process are made of wood, plastic, or steel and reproductibility is in the range of plus or minus 0.005 in.

Patterns are easy to repair since the material is easily welded by acetylene or arc welding techniques. It is easy to braze or silver solder, and

also takes lead-tin solder.

Involved in the process is the making of a master pattern and treating it with a release agent and then spraying the pattern with a special eutectic compound until approximately 1/2-in. thickness is formed. This is then stripped from the master pattern and the mold surface is placed face up in a special chamber.

All the atmosphere is removed from the chamber and replaced with carbon dioxide. The mold inside the chamber is then heated to 325-340 F. At this point the nickel carbonyl is introduced. Carbon monoxide is released and the original nickel in the carbonyl gas is deposited evenly on all surfaces of the mold or pattern.

—by L. C. Johnson

Eastern Canada Chapter

Honor Chapter Winners

Winners of the chapter's apprentice contest and technical paper contest were honored at the May meeting. Apprentice winners were:

Iron molding—M. Lefebvre, Dominion Engineering Works and R. Cahyu and G. Langevin, Montreal Technical School.

Bronze molding—G. Tremblay, Dominion Engineering Works; M. Duval, Three Rivers School of Technology; G. Drolet, St. Maurice Foundry.

Steel molding—G. Bergeron, Dominion Engineering Works.

Wood patternmaking—C. Wilkins, R. Barrette, and R. Wilkins, Dominion Engineering Works; and P. Laurin, National Pattern Works.

Michael A. Notte, Canada Steel Foundries, was awarded first place in the technical paper contest for his paper on "The Use of Exothermic Materials in the Manufacture of Steel Roll Castings." Max Reading, Foundry Services (Canada), Ltd., won second place for his paper on "Permanent Mould Castings."—by Jim Cherratt

Chesapeake Chapter

Gating and Riserings Castings

Principles of gating and risering were explained at the May meeting by Michael Bock, Exomet, Inc., Conneaut, Ohio.

Chapter members also honored W. H. Holtz, Railroad Production Div., American Brake Shoe Co. who retired in June. He was one of the founders of the chapter and served as chairman.

More than 200 members and guests attended the annual crab feast held June 11.—by V. R. Chastang



J. O. Trimble



PITTSBURGH—Low net winner in the golfing competition, D. B. Beath, Foundry Service Inc., left, accepts trophy from Jack Curran of Pennsylvania Glass Sand Corp., donor of the annual award.—by Walter Napp

AFS Chapter Meetings

AUGUST

British Columbia . . Aug. 6 . . Horseshoe Bay . . *Fishing Derby.*

Canton District . . Aug. 6 . . Brookside Country Club, Barberton, Ohio . . *Annual Picnic and Golf Party.*

Chicago . . Aug. 6 . . Nordic Hills Country club, Itasca, Ill. . . *Annual Golf Outing.*

Southern California . . Aug. 6 . . Lakewood Country Club, Lakewood, Calif. . . *Annual Stag Party.*

SEPTEMBER

Birmingham District . . Sept. 10 . . Cascade Plunge, Birmingham, Ala. . . *Annual Picnic.*

Detroit . . Sept. 22 . . Wolverine Hotel, Detroit.

Mid-South . . Sept. 9 . . Claridge Hotel, Memphis, Tenn.

Piedmont . . Sept. 9 . . Sedgefield Inn, Greensboro, N. C.

Pittsburgh . . Sept. 19 . . Webster Hall Hotel, Pittsburgh, Pa.

Quad City . . Sept. 19 . . LeClaire Hotel, Moline, Ill.

Timberline . . Sept. 21 . . Denver, Colo.

Twin City . . Sept. 12 . . Jax Cafe, Minneapolis.

Wisconsin . . Sept. 9 . . Schroeder Hotel, Milwaukee.

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Foundry Trade News

Gray Iron Founders' Society . . . 1960 design contest closed May 31. First place winner will receive \$500 in cash plus a citation at the society's annual meeting. Second place award is \$100 with a citation; the third through seventh place, \$50 cash plus a certificate of recognition.

Non-Ferrous Founders' Society . . . has appointed Dr. Richard A. Flinn, professor of metallurgical engineering, University of Michigan, Ann Arbor, Mich., as technical consultant.

American Society for Testing Materials . . . has announced two new tentative standards. One is for austenitic nodular iron castings. The other is for ferritic nodular iron castings for valves, flanges, pipe fittings, and other piping components.

New Jersey Zinc Co. . . . New York, is sponsoring a \$1000 cash award designated as the "New Jersey Zinc Co. Zinc Die Casting of the Year

Award." The award will be made Sept. 14 in Chicago at the annual dinner of the American Die Casting Institute to the person, who in the opinion of his employer, contributed most to the successful design and production of the part. Competition will end Aug. 30.

General Foundry Service Corp. . . . Oakland, Calif., will build a new and expanded plant at San Leandro, Calif., for the production of flasks and pattern plates.

Budd Co. . . . Philadelphia, has acquired the assets of Metrol, Inc., manufacturers of electromagnetic non-destructive testing equipment with headquarters in Pasadena, Calif. Metrol will continue to operate in California for the present as a new department of the Budd Co. Instruments Division.

M. A. Bell Co. . . . with offices in St. Louis and Houston, Texas, has been

appointed foundry sales representative for liquid concentrate, multiphase wetting compounds manufactured by Deynor Corp., Mamaroneck, N. Y. Representation will be carried out in Iowa, Nebraska, Kansas, Missouri, Oklahoma, Arkansas, Louisiana, and Texas.

Los Angeles Steel Casting Co. . . . has been purchased by the Shaffer interests of Brea, Calif. Aside from new ownership, no changes are planned in personnel or policies in the 58-year old organization.

Foundry Facings Manufacturers Association . . . recently appointed C. E. Herington, Herington Advertising, Inc., New Rochelle, N. Y., as secretary-treasurer.

Scientific Cast Products Corp. . . . has merged its two matchplate manufacturing plants into its main facility at 1390 E. 40th St., Cleveland.

General Electric Co. . . . will spend \$750,000 this year to modernize its foundry facilities at Elmira, N. Y. The new melting facilities will consist of two new hot-blast cupolas for gray iron melting. Also included will be modifications to building structures, new pouring equipment, an electric holding furnace, and charging equipment for lifting metal and coke into the cupolas.

Other steps in the multi-million dollar expansion and modernization program have included installation of new molding facilities and progressive mechanization for medium-range castings in the Elmira foundries at a cost of \$1,000,000; a \$4,300,000 construction program at the Schenectady foundries; opening of an applied research and development laboratory in Schenectady, an investment of \$750,000; and installation of \$1,600,000 in new facilities at the Everett foundries.

Dow Chemical Co. . . . Midland, Mich., has announced plans for a \$400,000 customer-service laboratory to demonstrate modern techniques for melting and casting magnesium. The laboratory is expected to go into full operation by Nov. 1. Equipment will include a 1500-ton and 500-ton die casting machines and a low-pressure permanent-mold operation now under development. The 1500-ton machine will produce castings weighing up to 20 pounds. The 500-ton machine is in the range size now most commonly used.

Babcock & Wilcox Co. . . . has signed

Observing the pouring of a small centrifugal casting are Paul Schneider, Wisconsin Centrifugal Foundry, Inc., and Dr.-Ing.-habil Gunther Schwietzke, J. G. Schwietzke Metallwerke, Dusseldorf, Germany. Dr. Schwietzke is president of the Germany foundry technical association and a past president of the International Committee of Foundry Technical Associations.



DUCTILE IRON SOCIETY—Officers and directors at annual meeting in May. Standing: E. C. Graham, R. K. Guise, James H. Lansing, Arthur Avedisian, S. F. Carter, H. J. South. Sitting: N. H. Minglehoff, G. W. Phelps, R. S. Thompson, William Beatty, J. R. Ludwig. Elected as directors but not shown: E. P. Trout, B. L. Baptist, and E. W. Aylward.

a dealer agreement with Denver Fire Clay Co. whereby the Denver firm will market Babcock & Wilcox refractories in Colorado, Wyoming, New Mexico, Utah, eastern Nevada, Idaho, and western Montana.

G. E. Smith, Inc. . . . Pittsburgh, Pa., has awarded a \$5000 grant to Duquesne University for chemical research by a graduate student.

Fulton Foundry & Machine Co. . . . Cleveland, has appointed F. H. White Associates, Detroit manufacturers' representative as sales agent.

Western Michigan University . . . Kalamazoo, Mich., has appointed a new advisory committee for industrial technology. Paul Rickman, Bard Tool & Equipment Co., Kalamazoo, is chairman. AFS Director T. T. Lloyd, Albion Malleable Iron Co., Albion, Mich., is a committee member.

Dollin Corp. . . . Irvington, N. J., has appointed Eynon Co., Detroit, as sales and engineering representatives for the state of Michigan, plus Toledo, Ohio and South Bend, Ind.

J. A. Weaver Co. . . . St. Louis manufacturer of electrical fittings, has started on the construction of a new foundry adjacent to the present plant. It will contain, in addition to production equipment, a laboratory for testing castings and sand control. The equipment is designed to make it the most fully-automated non-ferrous foundry in the midwest.

AiResearch Mfg. Div., Garrett Corp. . . . Los Angeles, the only west coast vertical centrifugal casting facility, is now available for precision aluminum casting of rotating equipment. These facilities are capable of casting, in high purity alloys, fans, turbine wheels, supercharger wheels, shrouded and unshrouded compressor wheels. The foundry was previously used exclusively for AiResearch products until its recent expansion.

Forest City Foundries Co. . . . Cleveland, has purchased the equipment and machinery of Dostal Foundry & Machine Co., Pontiac, Mich., which will move to Cleveland.

Sunbeam Equipment Corp. . . . Meadville, Pa., has appointed Dilcher Engineering Co., Atlanta, Ga., as sales representative for Sunbeam industrial furnaces and equipment in Georgia, Alabama, Tennessee, Mississippi, North Carolina, South Carolina, and the upper portion of Florida.

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Let's Get Personal...

Daniel E. Watkins . . . and Robert N. Voit, have been elected as vice-presidents of United States Pipe & Foundry Co., Birmingham, Ala. Watkins was associated with Sloss-Sheffield Steel & Iron Co., becoming general superintendent of blast furnaces and coke ovens in 1952, retaining this position when the company was merged with United States Pipe & Foundry Co. in 1952. Voit has been associated with the company since 1948. The following officers were re-elected: C. S. Lawson, president and chairman of the board; R. E. Garrett, executive vice-president; C. S. Northen, vice-president, sales; John W. Brennan, vice-president, secretary and treasurer.

Herbert L. Klopff . . . who has represented Thiem Products, Inc., as sales and service engineer is now named plant manager of the company's new subsidiary, Universal Refractories Corp., Greenville, Pa.

E. Walter Adams . . . has been promoted to manager of operations, eastern area plants, Kaiser Refractories & Chemicals Div., and Carey E. Lindsay has been named production manager for these facilities. They will be responsible

for administration and production at the five Kaiser eastern area plants at Columbiana and Niles, Ohio; Frostburg, Md.; Van Dyke, Pa.; and a new periclase facility being constructed at Midland, Mich. Adams and Lindsay will make their headquarters at Columbiana.

J. L. Doyle . . . has been named as buyer, foundry products and supplies, West Allis Works, Allis-Chalmers Mfg. Co., Milwaukee. For the past two years he has been on special assignment. He succeeds H. U. Mekeel, who resigned.

Ray C. Wing . . . has been appointed sales manager, Metal Working Machinery, Div., Oliver Machinery Corp., Grand Rapids, Mich. Wing has represented machine tool builders for several years in western Michigan.

Donald F. Rundle . . . is now manager, metallurgical development, Climax Mo-

lybdenum Co. Div., American Metal Climax, Inc. Rundle, formerly managing engineer of the Chrysler Corp. metallurgical research department, will be located in Chicago.

Glen T. Cahill . . . is now administrative assistant at Hamilton Foundry, Inc., Hamilton, Ohio. He joined the company in 1959 having been associated for two years with Arnco Drainage & Metal Products, Inc., Middletown, Ohio.

L. D. Alspach . . . has been promoted to manager of distribution sales for Alloy Sales Div., Brush Beryllium Co., Cleveland. In other changes, P. M. Christenson has been appointed sales engineer and R. H. Rozek named assistant to the manager of the division.

J. J. Fitzgibbon . . . has been appointed sales manager of the Whithead Metals, Inc., office at Harrison, N. J. Since 1953



D. E. Watkins



R. N. Voit



H. L. Klopff

EXECUTIVE REPORT '24

APPEARANCES CAN BE DECEIVING



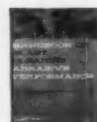
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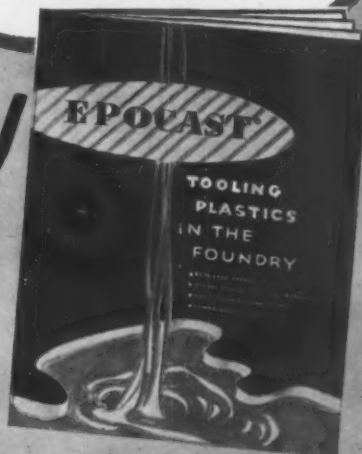
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Circle No. 154, Page 151

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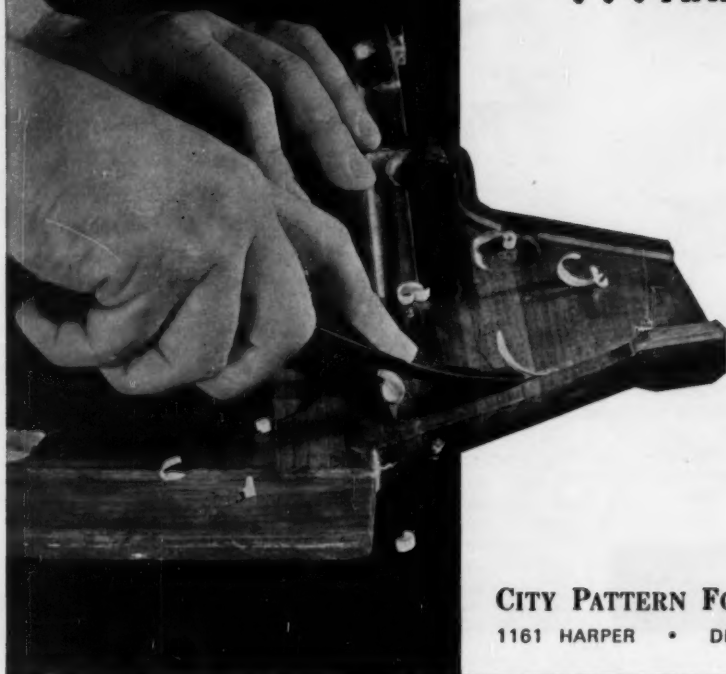
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Circle No. 165, Page 151

August 1960 139

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Circle No. 167, Page 151

he has been product manager of the foundry department.

Charles M. Brust . . . who recently retired as president of Eastern Malleable Iron Co., has received the McCrea medal of the Malleable Founders Society given to the individual judged to have contributed significantly toward the progress of the industry and the development of the art.

A. Donald Moll . . . has been appointed sales manager, Minneapolis Electric Steel Castings Co., Minneapolis. He was formerly assistant sales manager and manager of technical services and sales of high alloy and stainless steel castings.

W. V. Compton . . . has been named as vice-president and general manager of LaPorte Foundry Co., LaPorte, Ind. He

was formerly foundry superintendent. **Paul G. Schumm** has been named secretary and assistant treasurer succeeding **E. A. Miller** who retired after 43 years service. Schumm was formerly with Allis-Chalmers LaPorte works.

A. James Kiesler . . . of the General Electric Research Laboratory, Schenectady, N. Y., has been awarded the honorary professional degree of metallurgical engineer by the University of Missouri School of Mines and Metallurgy, Rolla, Mo. The degree was presented at the commencement ceremonies held May 29.

William B. Wallis . . . and **Ernest W. Weaver** have been given the Trinks award sponsored by the "Industrial Heating" publication for outstanding contributions. Wallis, consulting engineer for Strategic Materials Corp., N. Y., and formerly president of Lectromelt Fur-

nace Div., McGraw Edison Co., Pittsburgh, was cited for his inventions and engineering achievements in the electric arc melting furnace. Weaver, a mechanical engineer, and retired engineering executive of Surface Combustion Co., Toledo, was cited for achievements in design and construction of furnaces for heat treating metals.

J. Gerin Sylvia . . . has been promoted to senior instructor of the foundry department, Wentworth Institute, Boston. Prior to joining the faculty in 1958, Sylvia was manager of the H-B Foundry, Div., Hathaway Machinery Co., Fairhaven, Mass.

Roger Snellman . . . has been appointed manager of the Harbison-Walker Refractories Co. district sales office in Detroit. Since 1956 he has been sales representative in Los Angeles. **C. F.**



C. M. Brust



A. D. Moll



W. V. Compton



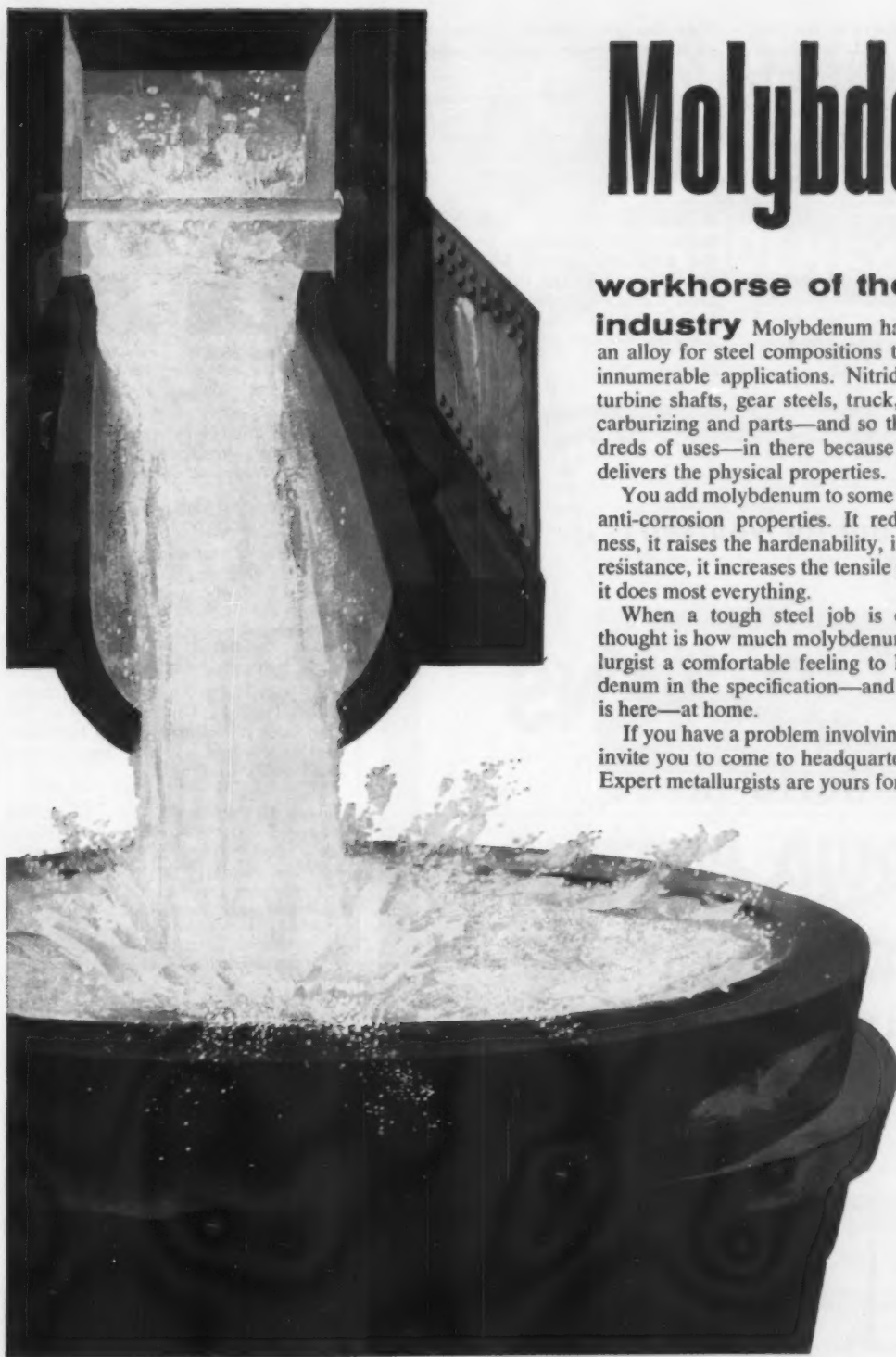
P. G. Schumm



A. J. Kiesler



W. B. Wallis



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Circle No. 139, Page 151

Wenrich, sales representative in the San Francisco office since 1951 has been named as manager of the new western district sales office with headquarters in Los Angeles.

Eugene R. Dean . . . has been promoted to assistant general superintendent, Coke & Iron Div., Pittsburgh Coke & Chemical Co. He had been superintendent of the company's blast furnaces at Neville Island.

David J. Pezdirtz . . . formerly with Battelle Memorial Institute as a metallurgical research engineer, has joined Globe Steel Abrasive Co., Mansfield,

Ohio, has chief metallurgist and manager of metal abrasive quality control.

John P. Holt . . . recently manager of market development, Basic, Inc., Cleveland, has joined Valley Dolomite Corp., St. Louis, as director of research and development.

H. Edward Ehlers . . . and Warren A. Zimmer, have been named as executive vice-presidents, Joseph Dixon Crucible Co., Jersey City, N. J. Each had formerly been a senior vice-president. Ehlers has been associated with the company since 1935 and Zimmer since 1936.

Glenn W. Merrefield . . . has joined the staff of Westover Corp., Milwaukee, and will be primarily connected with plant modernization and layout. He was formerly with Giffels & Rosetti, Detroit.



G. W. Merrefield



F. W. Bresette

Francis W. Bresette . . . formerly division pattern engineer, forge and foundry division, Chrysler Corp., Detroit, is now director of process engineering for Wisconsin Pattern Works, Inc., Racine, Wis.

A. Norman Swanson . . . has been appointed a manager of sales at the General Electric Co., Everett, Mass., foundry and will handle sales to customers outside of the General Electric departments.

F. Russell Stone . . . has become associated with North American Refractories, Ltd., Hamilton, Ontario, Can., as district sales representative with headquarters in Montreal. He was formerly with the Canada Fire Brick Co.

Joseph C. McHargey . . . has joined Superflux Mfg. Co., Allen Park, Mich., as a sales engineer in the Detroit area. He was employed by the Ford Motor Co. foundry division for 21 years and recently with Babcock & Wilcox Co.



obituaries

Edgar E. Ballard, 68, who retired in 1955 as chief engineer, Lester B. Knight & Associates, and continued with the organization as senior consultant, died June 22.

He had 48 years' construction, plant developments and consulting experience in railroad track, steel, gray iron, and non-ferrous foundries. Prior to joining Lester B. Knight & Associates in 1946 as chief engineer, he had been plant engineer National Bearing Div., American Brake Shoe Co., St. Louis, for many years. In addition to being active in AFS technical activities he served as chairman of the AFS St. Louis Chapter.



E. E. Ballard

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Future Meetings and Exhibits

Aug. 14-17 . . American Institute of Chemical Engineers and American Society of Mechanical Engineers, Heat Transfer Conference & Exhibit. Statler Hilton Hotel, Buffalo, N. Y.

Aug. 28-Sept. 2 . . Pennsylvania State University, Work Measurement Seminar. University Park, Pa.

Sept. 14-15 . . American Die Casting Institute, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 6-16 . . National Machine Tool Builders' Association, Machine Tool Exposition. International Amphitheatre, Chicago.

Sept. 19-23 . . Material Handling Equipment Distributors Association, Foundry Materials Handling Course. MHEDA National Training Center, Newport, R. I.

Sept. 19-24 . . International Foundry Congress. Zurich, Switzerland.

Sept. 22-23 . . National Foundry Association, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 27 . . American Management Association, Annual Meeting. Hotel Astor, New York.

Sept. 27-30 . . Association of Iron and Steel Engineers, Annual Convention & Exposition. Public Auditorium, Cleveland.

Oct. 12 . . Cast Bronze Bearing Institute, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 12-14 . . Gray Iron Founders' Society, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

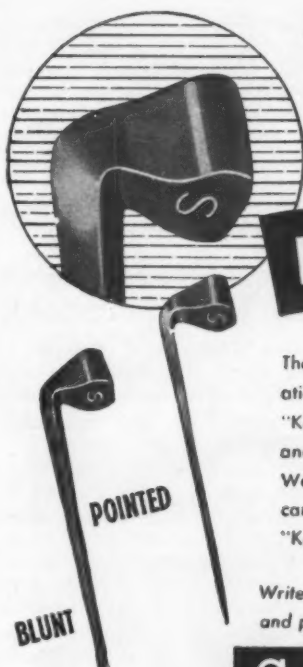
Oct. 13-15 . . Non-Ferrous Founders' Society, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 14-15 . . AFS New England Regional Foundry Conference. Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 17-18 . . Magnesium Association, Annual Convention. Pick Carter Hotel, Cleveland.

Oct. 17-21 . . American Society for Metals, Annual Meeting and Metal Exposition & Congress. Trade & Convention Center, Philadelphia.

Oct. 17-21 . . National Safety Council, National Safety Congress. Chicago.



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Koolhead 90°

The 90° bend under the head simplifies your operation and places the chill where it belongs. The "Koolhead 90°" will perform two duties: (1) a chill and (2) holding the sand on the surface of the mold. We feature clean, bright finished Horse Nails and can furnish the new bent head in any of the various "Koolhead" types.

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NEW BRIGHTON PA

Circle No. 169, Page 151

Orefraction

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Orefraction MINERALS INC.

P. O. BOX 247 — ANDREWS, S. C.

Circle No. 170, Page 151

August 1960 143

New Products and Processes

*Build an idea file for improvement and profit.
Circle numbers on literature request card, page 151,
for manufacturers' information.*

Copper-Base, Brass, Bronze Pellets Provide Faster Melting Operations

Copper base alloy brass and bronze pellets promote faster, improved melting and eliminate need to pile, pick up, carry, lift, and throw ingots. Melting is faster and charges denser be-



cause pellets fill voids. Pellets also aid in melting scrap return, gates, risers, and boring and mean less frequent charging and poking. Also said to permit closer analyses, greater uniformity, and fewer checks and controls. I. Schumann & Co.

For More Information, Circle No. 1, Page 151

Woven Glass Strainer Cores Filter Without Contaminating Scrap Metal

Strainer core made of woven glass, filters out undesirable oxides and foreign materials in non-ferrous castings. Material in the gate or bottom of a riser results in a weak plane when the casting is cooled. Riser or sprue can then be broken off with a hammer tap. Will not contaminate scrap metal as material floats off with the skim when remelted. Fibrous Glass Products Co.

For More Information, Circle No. 2, Page 151

Wide Range of Temperature Paints Feature Permanent Color Changes

Temperature indicating paint, applied by brush or spray gun, has the property to change its original color when certain temperatures are reached. Most color changes are permanent, making temperature obser-

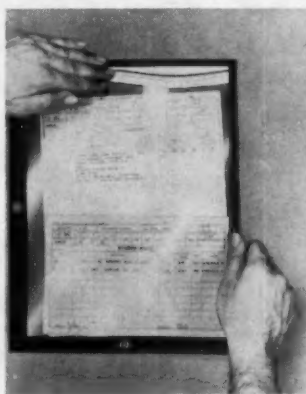
vations possible at any time after conclusion of the test.

Twenty-one paints, covering a measurement range of 104 F to 2462 F, provide a single color change when specific temperature points are reached. Fifteen other paints, covering a range from 131 F to 2912 F, undergo multiples of two, three, or four color changes at different levels, making it possible to visually obtain heat distribution data over large or intricate surfaces. Princeton Div., Curtiss-Wright Corp.

For More Information, Circle No. 3, Page 151

Transparent Job Ticket Envelope Keeps Contents Clean and Readable

Transparent job ticket envelope with zipper, seals out dust and grime keeping contents clean and readable.



Made in 10-1/2 x 13-1/2 in over-all size, envelope is made to be hung horizontally or vertically. American Kleer-Vu Plastics, Inc.

For More Information, Circle No. 4, Page 151

Temperature Indicating Stick Uses Holder for Preventing Damage

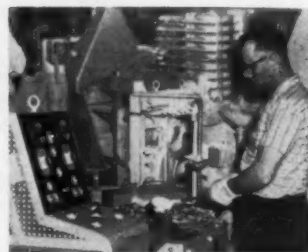
Temperature indicating stick utilizes new holder which protects against breakage and allows selection of any

length. Company also manufactures temperature indicators in pellet and liquid form with a total of 63 temperature ratings. Markal Co.

For More Information, Circle No. 5, Page 151

Portable, Automatic Permanent Mold Machines Feature Quick Die Changes

Portable, automatic permanent mold machines feature dual power unit which will operate two machines on same or separate cycles, or on automatic for one and manual on the other.



Power unit will also operate on two-way or three-way machines and operate casting machine and trimming press. Machines available for 8x12 or 12x18-inch plates. Dies are changed quickly, only two set screws need loosening for each half of mold. Timer may be moved to next furnace for a different alloy job. Stahl Specialty Co.

For More Information, Circle No. 6, Page 151

Magnetic Crack Detector Reveals Surface and Subsurface Cracks

Magnetic crack detector reveals sub-surface as well as surface cracks, flaws, and defects in any ferro-magnetic metal. Portable unit weighs 30



pounds and operated from a 110 v AC source or truck or auto battery. Units are available for operation from any other AC or DC voltage. United States Casting Repair Corp.

For More Information, Circle No. 7, Page 151

Push-Button, Continuous Car-Type Furnace Permits Faster Operations

Continuous car-type furnace used by large midwest foundry anneals castings, preheats before welding and stress relieves after welding in a push-button operation. The welding

pre-heat furnace holds five cars with the operator controlling doors by button. When the door is fully opened, car comes out of furnace. After one casting is removed, return button puts car back into furnace with door closing on return. When a casting is welded, a push button opens door in furnace B. When the door is completely open, car comes out. Casting is placed on car which is returned to the furnace with the door closing automatically. Both furnaces are capable of operating to 1650 F. One or both may be filled with castings and annealed after welding has been completed. Waltz Furnace Co.

For More Information, Circle No. 8, Page 151

Nickel Selenium Alloy Cuts Losses, and Simplifies Quality Control

Nickel Selenium alloy for degassifying and improved machinability, cuts selenium loss, reduces harmful selenium fumes, and simplifies quality control. Available as nickel-selenium bars or lumps, ferro-selenium lumps or selenium metal powder. Eastern Alloys Corp.

For More Information, Circle No. 9, Page 151

Resin for Hot-Processed Sand Coating Promotes Fast Curing

New stable novolac resin developed for hot-processed sand coating allows for faster cures and freedom from shell warping or cracking. Melt viscosities of the resin provide proper flow for higher shell or core strength, shell weight pick-up in rapid investment cycles and optimum green strength on pattern plates. Union Carbide Plastics Co., Div. Union Carbide Corp.

For More Information, Circle No. 25, Page 151

Preheat Furnace Uses Automation to Cut Car Wheel Production Time

Preheat furnace speeds production of railroad car wheels through automation. Car wheels automatically conveyed into the preheat furnace, brought quickly to desired temperature and automatically conveyed into a rotary hearth furnace. Industrial Div., Lindberg Engineering Co.

For More Information, Circle No. 10, Page 151

Integral Dust Collector Eliminates Pressure Build-Up Characteristics

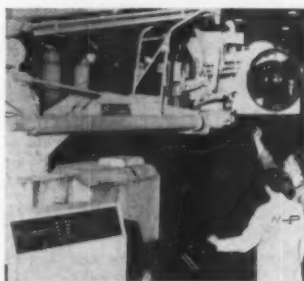
Integral dust collector with no filter to change is reported to handle high concentrations of dust, over a wide range of particle sizes, by using 2-in. dia. tubes of a new design installed in multiple to capacity required. Developed to remove dust

in grinding, buffing, polishing, milling and cutting operations, the unit has constant suction at hood. Collector has no pressure build-up characteristic so that dust is continuously removed from the path of flow and discharges downward into a secondary receiver that requires infrequent attention. Aerotec Industries, Inc.

For More Information, Circle No. 11, Page 151

Magnetic Tape Allows Duplication of Operations in Foundry Equipment

Magnetic tape control system allows automation of heavy foundry equipment, demonstrated with sand-



slinger in photo. Operator sets path with first run, thereafter tape duplicates the original movements. Micro-Path, Inc.

For More Information, Circle No. 12, Page 151

Flame-Proof, Aluminized Gloves Have Heat-Reflecting Qualities

Flame-proof aluminized gloves reflect 90 per cent of all radiant heat. Gloves have leather palms and aluminized asbestos backs and thumbs. Backs are a combination of asbestos



and special heat resistant fabric. Gloves are light, flexible, fully insulating and will not crack or peel. Available in three styles as lined or unlined. Air Reduction Sales Co., Div. Air Reduction Co.

For More Information, Circle No. 13, Page 151

Belt-Disk Machine Performs 90 Per Cent of Finishing Operations

Belt-disk finishing machine said to

be capable of performing 90 per cent of all shop finishing operations, uses standard 4-in. abrasive belt and 12-in. abrasive disk. Unit enables operator to move from one machine to the other in seconds, as required when finishing curved, straight or irregular shaped parts. Particularly suited for sharpening tools as idler drum guard facilitates hollow grinding; no wheels to dress and quenching in water is not necessary. Delta Power Tool Div., Rockwell Mfg. Co.

For More Information, Circle No. 14, Page 151

Analyzer Gives Rapid Determination of Hydrogen Content in Aluminum

Determination of hydrogen content of molten aluminum in one minute is possible by use of initial bubble principle. A small quantity of molten

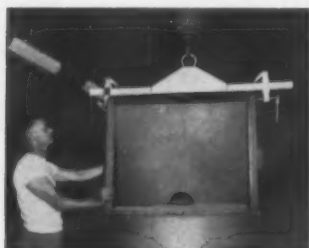


aluminum is ladled into a small electric vacuum furnace. As the furnace is evacuated at a predetermined rate, measurements are made of vacuum and temperature. From these figures and reference to nomographs, an accurate indication of the gas content is made. Meltronics, Inc.

For More Information, Circle No. 15, Page 151

Special Clamp-on Lifting Tools Speed Casting Handling Operations

Clamp-on lifting tools, lift, transfer, pull, turn over, rotate, and position castings and other objects. Tools are



rapidly and firmly clamped to various shapes by hand and will not lose their grip until manually loosened. Three basic grips are used. James Campbell Smith, Inc.

For More Information, Circle No. 16, Page 151

New Wood Flour Creates No Dusting

Dust-free wood flour, having identical properties as the company's line

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these
extra ✓
jobs**



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CONVEYORS
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You can do more than simply convey bulk materials by using specially designed AJAX Conveyors...

- ☐ SORT, SCREEN, OR SCALP while traveling over conveyor pan.
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Write for full information and name of local AJAX man.

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Circle No. 177, Page 151

146 modern castings

of regular flour, plus the ability to remain free from dust diffusion when used, has been made available. Samples furnished. Penn-Rillton Co.

For More Information, Circle No. 17, Page 151

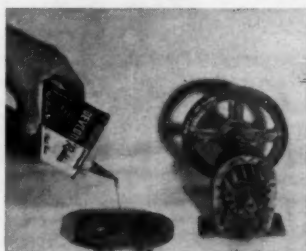
Explosion-Proof Electric Vibrator Has Adjustable Vibration Impact

Explosion-proof vibrator electrically operated moves stubborn materials through bins, chutes and hoppers. Vibration force is produced by eccentric weights fastened on each end of the rotating motor shaft. Vibration impact can be adjusted from 385 to 1100 lb with several separate settings. Cleveland Vibrator Co.

For More Information, Circle No. 18, Page 151

Tough, Flexible Rubber in Paste Form has High Chemical Resistance

Rubber in paste form for general repair work is tough, permanently flexible, waterproof, fast setting and unaffected by oil, gasoline, and most



chemicals. Use for sealing or caulking around machinery, as a coating to protect machinery against rusting or corrosive liquids, and for repairing torn conveyor belting. Squeezed on, or applied by brush. Devcon Corp.

For More Information, Circle No. 19, Page 151

Small-Sized Billets for Stainless Steel Melting Simplify Additions

Small-sized billets for stainless steel and alloy melting simplify melt additions. Manufactured in various sizes and in over 30 different specifications. Smaller sizes packed in 100-lb kegs, larger units packed in special skids. Dreifus Steel Corp.

For More Information, Circle No. 20, Page 151

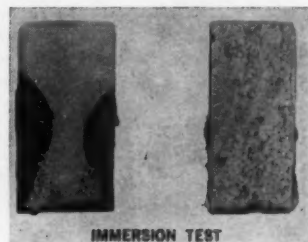
Three-Stage Continuous Sand Mixer Features Full-Width Muller Wheel

Three-stage mixer by Pekay Machine & Engineering Co., Chicago, uses bladed wheels travelling at 500-600 rpm to continuously mix increments of bonds, new sand, and shakeout sand.

For More Information, Circle No. 21, Page 151

Refractories and High-Alumina Motor Aid in Aluminum Melting

Aluminum melting refractories and high-alumina motor, ease destructive impact accompanying furnace charging, retard excessive corrosion of the furnace parts and avoid contaminants. Alumina in stabilized crystalline form is the main constituents of the refractory brick.



In its several modifications for specific conditions, it is phosphate bonded, chemically, or hard-fired with the phosphate bond or made with a ceramic bond developed by high temperature firing. Harbison-Walker Refractories Co.

For More Information, Circle No. 22, Page 151

Chemical Additive Increases Shell Core Strength up to 50 Per Cent

Tensile strength of foundry shell cores and molds is increased as much as 55 per cent by a chemical additive which is used in the cold coating of foundry sands where the resin, usually phenolic, is solubilized in a suitable solvent, and mixed with the sand and a curing agent.

It is added to the resin sand mix and the solvent evaporated, leaving behind a dry coated sand mixture. The additive was especially developed for use with alcohol soluble thermosetting resins. Heyden Newport Chemical Corp.

For More Information, Circle No. 23, Page 151

Fully Automatic Shell Core Blower Features Safety, High Production

Shell core blower, fully automatic, complete with self-contained electric control panel, uses two standard size, interchangeable, thermostat controlled heater plates for core boxes up to 14x17x20 inches or 14x20x25 inches. All movements are hydraulically controlled including a core-ejecting flip plate.

At no time does operator have hands between heater plates. Machine is reported fast-acting and easy to operate. Quickly changed from fully automatic to single cycle control. F. E. North America, Ltd.

For More Information, Circle No. 24, Page 151

New Books for You . . .

The Manufacture of Iron and Steel, Volume Three—Steelworks Fuels, Furnaces, Refractories & Instruments . . . G. Reginald Bashforth. 246 pp. Chapman & Hall, London. 1960. Both a textbook for students and a reference book for busy industrialists. Provides information useful to metallurgists, furnace engineers, and fuel and instrument technologists.

Metal Industry Handbook and Directory 1960 . . . 568 pp. Iliffe & Sons, Ltd., London. A reference handbook covering general properties of metals and alloys, general engineering data and tables, descriptions of electroplating and allied processes, and a directory of trade names, associations, and products.

How to Build Profits by Controlling Costs . . . 48 pp. Dun & Bradstreet, Inc., New York. 1960. This booklet presents a step-by-step procedure for the small businessman to use in examining and controlling the costs of his business.

Cast Bronze Bearing Design Manual . . . Harry C. Rippel, 72 pages. Cast Bronze Bearing Institute, Inc., 1604 Chicago Ave., Evanston, Ill. 1960. Single volume contains the latest theoretical and experimental information on bronze bearing design. Manual simplifies the complex interrelation of many variables and cuts through complications by use of 15 tables, 57 figures, and sample calculations. Detailed explanations tell how to predict load-carrying capacity, power requirements, lubrication requirements, stability, and operating temperatures. Bearing clearances are recommended for various classes of machinery and shaft sizes. Spe-

cial problems caused by shock loads and heavy loads at slow speeds are analyzed. Also presents additional information on lubricating fluids, including a method for calculating viscosity.

Physical and Engineering Properties of Cast Iron . . . Harold T. Angus, 528 pages. British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, England. 1960. Of practical value to those dealing with day-to-day problems of iron founding and engineering as well as to research workers, technical colleges, and technical reference libraries. Contains 150 pictures, photomicrographs, diagrams, and charts. Supporting data presented in convenient tabular form. Book is divided into nine parts: constitution and structure; mechanical, physical and electrical properties; general properties of commercial cast irons; special properties affecting surface; heat treatment of gray cast iron; internal casting stresses; components with high local loadings; and cast iron beams, columns, pipes, cylinders, and pressure vessels.

Routine Analysis of Copper Base Alloys . . . Frank J. Versagi, 168 pages. Chemical Publishing Co., 212 Fifth Ave., New York. 1960. Written for the laboratory worker, whether chemist or technician, presenting those methods which have proved most effective in metal analytical laboratories. The methods are designed for production control as well as acceptance or rejection of incoming material. Each method is complete in itself in step-by-step form from the weighing of the sample to final calculation, without referring to other sections or pages.

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Circle No. 171, Page 151

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Industrial TYPE 592T

Type 592T, standard ladle recommended for automated production, is simple, safe, strong and dependable.

This ladle with Industrial Universal Bail eliminates gear bind and drag — frees the Foundryman forever from all heat distortion troubles.

Bail connection needs no lubrication or adjustments. Trunnion bearings have perfect freedom of movement within carefully determined limits. Result: A ladle with longer, more profitable life, immeasurably greater ease of operation than is assured in any other equipment.

Industrial EQUIPMENT COMPANY

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Circle No. 172, Page 151

August 1960 147

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For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid.

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INVESTMENT CASTING FOREMAN—ferrous and non-ferrous, experienced in all phases. Good opportunity, New York area. Send resume and salary requirement. Box H-104, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.

SALES REPRESENTATIVE FOR PITTSBURGH AREA—to sell foundry materials, refractory coatings, core oils, cold curing, and self set binders. Sand control experience and knowledge of foundry sand practice required. Send resume to: Thiem Products, Inc., 9800 West Rogers St., Milwaukee 19, Wisconsin.

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INDUSTRIAL ENGINEER—Opportunity for graduate engineer experienced in methods and time standards for a large diversified steel foundry in New England. Foundry experience important but not essential. Must be capable of supervising small group. Salary commensurate with qualifications. Send resume to: Box H-109, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

RESPONSIBLE POSITION AS CHIEF METALLURGIST—available at once. Set up own department. Gray iron mechanized foundry. Call collect: REDwood 1-2400, H. T. Britton, Taylor & Boggis Foundry, Cleveland, Ohio.

MANAGER-SUPERINTENDENT — Mid-west non-ferrous foundry, over \$1,000,000 annual sales. Floor and production molding in sand, aluminum permanent mold and heat-treating. Position backed by staff for departmental budget, quality, metallurgical control, methods, standards. Young, aggressive management planning for growth. State experience, qualifications, salary. Box H-114, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

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WORKS MANAGER—or foundry superintendent—non-ferrous. Able to take charge of all phases of operation including x-ray. Twenty-one years of practical experience in all phases of non-ferrous foundry work. This includes plaster molding and waterless sand casting technique. Box H-112, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

PRECISION FOUNDRY MANAGER—United Kingdom—seeks change Light alloy castings, aircraft, commercial. Excellent technical qualifications. Main abilities—enthusiasm, experience, patterns, models, runners, feeders, plaster, shell, sand. Box H-100, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.

PRECISION CASTING METALLURGIST—with international reputation and over 20 years of ferrous and non-ferrous experience in permanent mold, centrifugal casting, plaster, and waterless molding sand. Available as technical consultant. Box H-111, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

GRAY IRON FOUNDRY SUPERINTENDENT OR GENERAL FOREMAN—Age 55 years—34 years of experience in all departments. Jobbing or production work. Synthetic or natural bonded sands. Estimates from blue prints. Five years in the capacity of General Foreman and 8 years plant superintendent of two foundries and machine shop. Box H-102, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.

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ONE MODEL 3F SIMPSON MIX-MULLER—60 cu. ft. batch, used four years, excellent condition. Address Box H-109, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

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SOUTH AMERICAN PRODUCTION IRON FOUNDRY AND MACHINE SHOP—invites American foundryman to invest 50-100,000 dollars, contributing also with products to existing manufacturing program. Good profits. Write to: Apartado Aereo 4151 Bogota, Colombia.

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For The Asking

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for manufacturers' publications.

Pneumatic production . . . equipment brochure offers specifications for grinders, sanders, reamers, screwdrivers, nutrunners, filing tools, and cutting tools. Aire-tool Mfg. Co.

For Your Copy, Circle No. 49, Page 151

Titanium . . . booklet, 36 pages, is designed as reference for engineers, metallurgists and designers who desire the latest technical information. Harvey Aluminum Co.

For Your Copy, Circle No. 50, Page 151

Talks on tape . . . Metal casting technology in form of talks given before AFS meetings have been recorded. Circle number below for complete list and prices. American Foundrymen's Society.

For Your Copy, Circle No. 51, Page 151

Temperature conversion . . . chart, wallet-size, with easy-to-read tables of Fahrenheit and Centigrade temperature equivalents. Moeller Instrument Co.

For Your Copy, Circle No. 52, Page 151

Microscopic photography . . . data book of the elementary photomicrographic technique available in a revised edition. Eastman Kodak Co.

For Your Copy, Circle No. 53, Page 151

Inoculants . . . for cast and ductile iron described in booklets which use pictures, graphs, and tables to show advantages. Electro Metallurgical Co., Div. Union Carbide Corp.

For Your Copy, Circle No. 54, Page 151

Ferrous metallurgy guide . . . offers

FOUNDRY METALLURGICAL ENGINEER

An excellent position is open in the Los Angeles area for a man with at least 10 years experience.

Prefer a graduate metallurgist with ferrous foundry background in stainless steel precision investment casting.

Vacuum furnace casting and non-ferrous experience also highly desirable.

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Circle No. 173, Page 151

August 1960 149

principal characteristics of steels represented across the temperature range to 2900 F. Tempil Corp.

For Your Copy, Circle No. 62, Page 151

Ductile irons . . . booklet, 28 pages, is complete with information, applications and specifications of these new cast metals. International Nickel Co.

For Your Copy, Circle No. 63, Page 151

Attract customers . . . build customer and employee loyalty, and other aspects of public relations covered in new booklet. Offers 33 basic ideas. Action Advertising Corp.

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Malleable iron . . . facts and uses discussed in bulletin featuring use of malleable iron in 1960 automobiles. Malleable Founders Society.

For Your Copy, Circle No. 65, Page 151

Use a hand camera . . . to take photomicrographs. Read this bulletin to learn how easy it really is. Eastman Kodak Co.

For Your Copy, Circle No. 66, Page 151

Wall Chart . . . lists decimal equivalents of fractions of an inch—1/64 to 1 in. Use the Literature Request Card for your free chart. Ohio Seamless Tube Div., Copperweld Steel Co.

For Your Copy, Circle No. 67, Page 151

Centrifugal casting . . . process fully explained and illustrated in 8-page booklet. Centrifugal Casting Co.

For Your Copy, Circle No. 68, Page 151

Core processes . . . reprint, 6 pages, discusses four major core making processes with a comparison of advantages and disadvantages of each. Archer-Daniels-Midland Co.

For Your Copy, Circle No. 69, Page 151

Alloy analysis chart . . . features sliding rule giving you instant analysis of over 125 super alloys, cobalt alloys, and nickel chrome alloys. Security Alloys Co.

For Your Copy, Circle No. 70, Page 151

Pinholes or inclusions . . . is the title of newsletter which discusses inspection, causes, inclusions, improperly cleaned ladles, and other factors causing these faults. American Colloid Co.

For Your Copy, Circle No. 71, Page 151

Aptitude test . . . designed to give quick indication of applicant's ability to manipulate numbers; request information. Aptitests.

For Your Copy, Circle No. 72, Page 151

Motor couplings . . . feature geared flexible design, new corrosive-resistant cover, and lighter weight. Request folder. Link-Belt Co.

For Your Copy, Circle No. 73, Page 151

X-ray sheet film processing . . . is reportedly accomplished in six minutes with new processor. Eastman Kodak Co.

For Your Copy, Circle No. 74, Page 151

Your safety program . . . may get a shot in the arm after reading this 96-page booklet illustrating methods and promotions for successful programs. Send for information. National Safety Council.

For Your Copy, Circle No. 75, Page 151

Multipoint recorder . . . permits change from 2 to 24 points within seconds. Completely detailed in 4-page specification. Minneapolis-Honeywell Regulator Co.

For Your Copy, Circle No. 76, Page 151

Future design . . . for fork lift trucks are combined with today's latest equipment in this 12-page brochure. Automatic Transportation Co.

For Your Copy, Circle No. 77, Page 151

Worker fatigue . . . can cost you dollars. Learn what causes it and what you can do about it in government bulletin. Small Business Administration.

For Your Copy, Circle No. 78, Page 151

Gas, LP gas, and diesel . . . lift trucks, 2000 to 10,000-pound capacities, covered in new 2-page catalog. Another 2-page catalog describes company's diesel lift trucks in 3000 to 8000-pound capacities. Allis-Chalmers Mfg. Co.

For Your Copy, Circle No. 79, Page 151

Foundry equipment . . . molding machines, sand systems, sandrammer installations, and sand mulling machines presented in new bulletin. F. E. (North America) Ltd.

For Your Copy, Circle No. 80, Page 151

Industrial truck maintenance . . . is subject of company house organ. Emphasis is given to ways of reducing maintenance and downtime costs. Elwell-Parker Electric Co.

For Your Copy, Circle No. 81, Page 151

Photomicrography print . . . development is subject of article featured in company house organ. Buehler Ltd.

For Your Copy, Circle No. 82, Page 151

Non-ferrous alloys . . . specified in bulletin as to chemical analyses and minimum physical properties. Centrifugally Cast Products Div., Shenango Furnace Co.

For Your Copy, Circle No. 83, Page 151

One man crew . . . is term for materials handling system wherein each dock employee works alone; he is his own checker, stripper, and loader—working with this industrial truck. Lewis-Shepard.

For Your Copy, Circle No. 84, Page 151

Protective fluxes . . . for aluminum and its alloys presented in new brochure offering properties, uses, and complete index to 12 major grades of product line. Foundry Services, Inc.

For Your Copy, Circle No. 85, Page 151

Fork truck mast . . . is an extra-high lift, hydraulically-operated unit with normal collapsed-mast height headroom

clearance. Available on gas and electric models. Yale & Towne Mfg. Co.

For Your Copy, Circle No. 86, Page 151

Shell core . . . advantages in new V-8 truck engines produced by heavy materials handling equipment manufacturer are shown in case history report. Durez Plastics Div., Hooker Chemical Corp.

For Your Copy, Circle No. 87, Page 151

Equipment leasing . . . for smaller manufacturers is subject of revised edition of 24-page booklet. Discusses "pros and cons." Foundation for Management Research.

For Your Copy, Circle No. 88, Page 151

Automation technology . . . is subject of 16-page publication which also includes discussions on economics of automation and automation equipment. General Electric, Industrial Electronics Div.

For Your Copy, Circle No. 89, Page 151

Greater speed control . . . and operator safety are reportedly built into company's 7000-pound capacity industrial truck, discussed in new 4-page folder. Elwell-Parker Electric Co.

For Your Copy, Circle No. 90, Page 151

New dust collector . . . line presented in 6-page bulletin featuring collector selection nomogram. American Radiator & Standard Sanitary Corp.

For Your Copy, Circle No. 91, Page 151

Judging engine quality . . . discussed in 28-page handbook emphasizing features of various designs which provide you with top performance for minimum cost. Caterpillar Tractor Co.

For Your Copy, Circle No. 92, Page 151

Free reprints

The following reprints of feature articles which appeared in MODERN CASTINGS are available to you free of charge. Use the Literature Request Card.

Hot properties . . . of molding sand discussed as to hot strength, minimum expansion, and hot deformation in reprint from MODERN CASTINGS. American Foundrymen's Society.

For Your Copy, Circle No. 93, Page 151

Automatic control . . . of sand moisture to achieve closer control of variables is subject of MODERN CASTINGS reprint. American Foundrymen's Society.

For Your Copy, Circle No. 94, Page 151

CO₂ molding . . . is the basis of this study to determine optimum quantity of sodium silicate binder in relation to collapsibility in cores and molds. Reprint from AFS TRANSACTIONS. American Foundrymen's Society.

For Your Copy, Circle No. 95, Page 151

Proposed international classification . . . for ferrous cast metals is presented in this article reprinted from MODERN CASTINGS. American Foundrymen's Society.

For Your Copy, Circle No. 96, Page 151

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Track roller frame and integral diagonal brace (pictured on the cover) may be seen in these two views of crawler-tractor.

Our August Cover . . .

Unitized Stress Flow— A New Casting Design Concept

Unitized "stress flow" construction with steel castings is meeting new demands placed on heavy-duty earth-moving machinery. Developed by the Eimco Corp. of Salt Lake City, stress flow is a new design mechanism in which steel castings are so shaped that internal stresses and applied load stresses flow evenly throughout the structural member. With properly designed steel castings, areas of stress concentration are eliminated so maximum strength and rigidity are achieved with minimum weight. Their equipment designers are trained to think and design in terms of cast steel.

The company is a leading advocate of the use of steel castings to build dependability into crawler-mounted tractors. In fact, they believe that full use of steel castings can most economically produce a machine with best design, service, and maintenance traits. As a consequence Eimco crawler tractors use more cast steel parts than any other.

Pictured on the cover is a track roller frame and its diagonal brace made as a single steel casting by Eimco. Two of these castings are shown above, mounted on the under-

neath side of a crawler tractor. Also visible is the massive single-piece main frame—center housing—twin final-drive housing.

As heavier loads are placed on lighter castings, foundrymen are staying one jump ahead of the proverbial straw by redesigning. Stress analysis is one of the newest aids to improved design. Besides observing stress patterns on static loaded castings it is not uncommon to attach strain gauges to critical tractor parts and record their stress and strain ordeals during a day's work. A new era in casting design is being opened as the result of these on-the-spot dynamic loading studies. Now they are putting the metal where it's needed and taking it away from unstressed areas. And the result is a lighter but stronger casting.

When it comes to moving mountains of earth to level highway roadbeds, dam lakes, clear land, and strip burden from minerals, you need equipment which is really rugged. Steel castings are being used extensively in the heavy-duty machinery which is meeting the challenge of the irresistible force and the immovable object.

How's Business...

Going Up...

Output per man-hour rose four per cent in 1959, according to Bureau of Labor statistics. Productivity, a barometer for wage increases by labor unions, is a comparison of the dollar value of goods and services produced with the hours of all private industry workers engaged in production. Signs point to a continued productivity increase in the first quarter of 1960.

A bright economic outlet for the rest of 1960 was indicated by an American Bankers Association nationwide survey of business and credit. Public building is at a high level; commercial and industrial construc-

tion shows a moderate increase; but home building is slowing down because of higher costs.

Aluminum production is up to 84 per cent of capacity—a gain of nearly six points during 1960. Automobiles and homes are using more of the light metal. First quarter exports are six times that of the same period in 1959.

Highway building is being stimulated by the Commerce Department announcement that states can double the amount of federally assisted road construction contracts issued in the three months July-September. This action should give a lift to sluggish high-

way activity this summer. Many foundries contribute either directly or indirectly to this 41,000-mile interstate network under construction. Some 9000 miles of it were already completed by March 31.

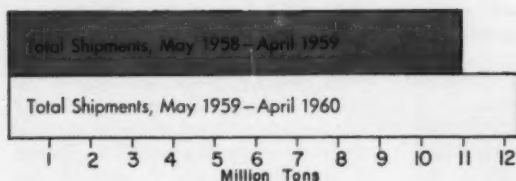
First quarter capital appropriations reached \$3.8 billion—a five per cent rise over 1959 first quarter, according to Newsweek Quarterly Survey of Capital Appropriations. About 26 per cent of these appropriations were earmarked for new plants, balance for new machinery and equipment. An appropriations backlog of \$9 billion indicates enough to keep spending at current rates for another 12 months

For the third straight month dollar volume of orders booked by industrial materials handling equipment manufacturers showed an increase. This is the highest point attained since June, 1959. The Mate-

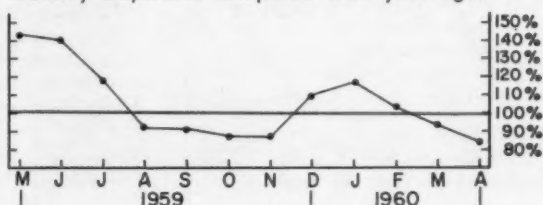
Trends in Metalcastings Shipments

Statistics from Bureau of the Census, U. S. Department of Commerce

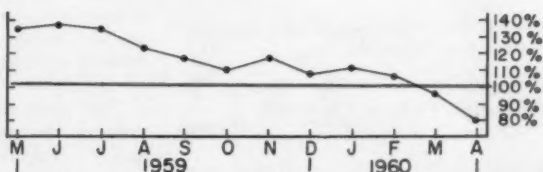
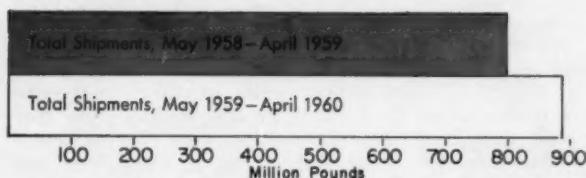
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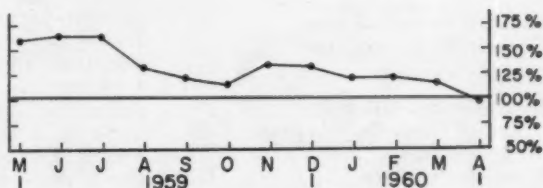
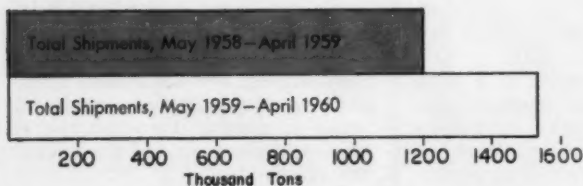
Monthly shipments compared with year ago.



MALLEABLE IRON



STEEL



rial Handling Institute attributes the boom to strong industry trend toward installing more labor-saving equipment in the area of material handling.

A 15.3 per cent rise in third-quarter freight car loadings over the year earlier has been predicted by the Association of American Railroads. Biggest expected gain will be in hauling ore and steel. A good barometer of business activity, the Association also estimated the second-quarter loadings would be up 0.5 per cent.

Going Down . . .

Steel output fell to 55 per cent of capacity in the last week of June—lowest ebb in two years for a non-strike work week. Vacation schedules and customer inventory cutting are blamed for this new low. Operations will probably "bottom-out" in July with improvement expected in August. Foundries are suffering since

castings are often the important components that hold together many a steel fabrication.

Machine tool orders dropped again in May to the lowest point since January, 1959. May shipments, however, were ahead of April and also May a year ago. Foreign demand is offsetting a part of this drop.

Quotable Quotes . . .

"At least 120 million pounds of aluminum castings will be required for compact automobile engines during the 1961 model year."—James M. Smith, Aluminum Company of America, Cleveland.

"At our oxygen furnace shop at Aliquippa, in the month of May, we produced steel at an average rate of 111 tons per hour. Compare this with approximately 40 tons per hour which is the best average rate of produc-

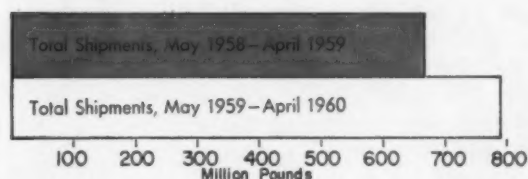
tion in the most modern open hearth shop."—C. M. Beeghly, President, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Metallurgical engineers graduated from Lehigh University last week will receive an average starting salary of \$520—five per cent higher than last year."—E. A. Teal, Lehigh University, Bethlehem, Pa.

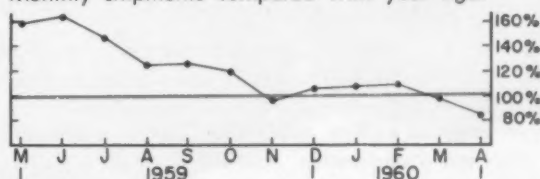
Metalcasting Shipments . . .

The charts below indicate a rather sharp slump in castings shipments for most classifications shown. Graphs in right hand columns show that percentages of casting shipments for April 1960 compare to shipments of April 1959 as follows: aluminum, 85 per cent; copper, 80 per cent; zinc, 84 per cent; magnesium, 76 per cent; gray iron, 84 per cent; malleable iron, 83 per cent; and steel, 89 per cent.

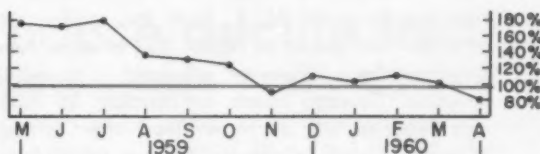
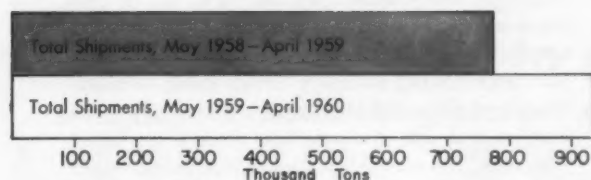
ALUMINUM



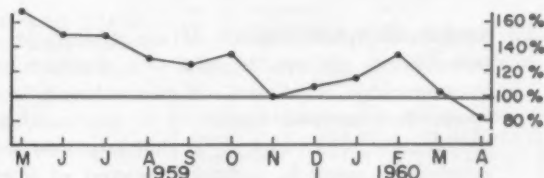
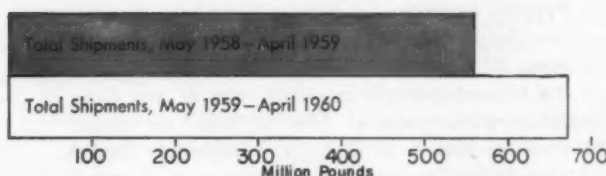
Monthly shipments compared with year ago.



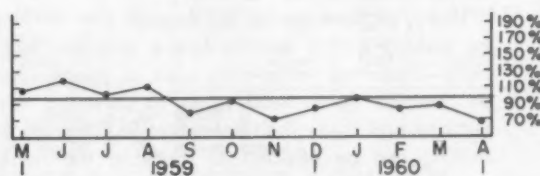
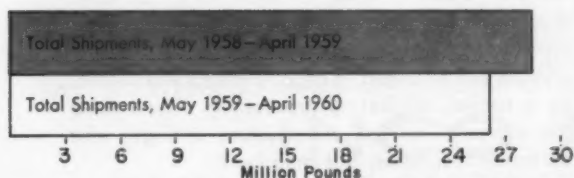
COPPER



ZINC



MAGNESIUM



The Editor's Report

by *Jack Schaum*



Do You Know:

- 1) Why inoculating gray iron increases its shrinkage?
- 2) How to gain 20 per cent in productivity of pour and shakeout workers?
- 3) What a nickel-carbonyl pattern is?
- 4) How to achieve "Management by Objective"?
- 5) That an appreciable aluminum and calcium content in ferrosilicon improves its inoculating power?
- 6) Who is casting thin-walled airplane wings, automobile hoods, railway car panels, and boat hulls?

All this and more can be gained by reading this month's MODERN CASTINGS. Improve your foundry practices by benefiting from the experiences of experts. Remember, success is a journey—not a destination. And MODERN CASTINGS is your road map for the trip.

CO₂ Process Sand . . . does not have to be used immediately after mixing. Oberdorfer Foundry, Syracuse, N. Y., uses the sodium silicate bonded sand in both its Syracuse and Oswego plants. However, all sand is mixed in Syracuse. Oswego needs are trucked 35 miles and used as late as three days after mixing. If proper handling precautions are taken—keep heat and air away from the sand—properties show no appreciable deterioration.

Sand-metal hybrid molds . . . are in need of a better name, perhaps. In spite of a shortcoming in terminology, aluminum and magnesium foundrymen find extreme versatility in this molding technique in which cast metal chill segments are rammed in sand. By judicious locating of iron, bronze, or aluminum chills in the mold, you can synthesize directional solidification without redesigning the casting.

Heavy sections can be fed through thin sections by placing a chill on the heavy sections. Anti-chills—insulating refractories such as plaster—can be rammed up in sand so as to surround thin sections and delay their solidification. Degrees of chilling can be effected by burying the metal

chill in sand any desired depth away from the mold-metal interface.

Similar effects can be achieved by applying varying thicknesses of refractory washes on the chills. The high thermal gradients induced by chills can produce denser, finer grained metal with remarkably better properties than achieved when casting cools slowly in sand mold. Work at M.I.T. (see Modern Castings, June 1958, pp 45-50) demonstrated how magnesium alloy AZ91C cast into sand-metal molds had its tensile strength raised 70 per cent, yield strength increased 34 per cent and elongation upped 400 per cent. So the next time you tackle a configuration that seems to defy sound casting, remember you don't necessarily have to redesign the casting. Instead, redesign the heat flow characteristics of the mold with chills and anti-chills.

Aluminum brake drums . . . are now being made in a new alloy—X392 (19% Si, 0.6% Cu, 1.0% Mg, 0.4% Mn, balance Al). Suited to die or permanent mold casting, the aluminum drums show satisfactory machinability, brake surface condition, and braking efficiency. Brake lining temperatures and fading are reduced substantially since aluminum drums dissipate heat three times faster than iron. The aluminum alloy is also being tested in cylinder liners and blocks, pistons, sheaves, and pulleys.

Pyrolytic graphite . . . a material so new that the foundry industry hasn't decided where it can be used. Above 3000 F. this unusual graphite has the highest strength-to-weight ratio of any high-temperature material now in use. Its tensile strength above 5000 F. is a fabulous 40,000 pounds per square inch. Possible uses in metal-casting include crucibles, permanent molds and dies, patterns, and refractories. Produced by the General Electric Research Laboratory, pyrolytic graphite owes its high temperature strength, inertness, and density to the fact that the graphite crystals are arranged in orderly stacks and layers, by a special fabricating process. So if you need the ultimate in high temperature strength and corrosion resistance, this may be it.



Most effective way to produce ductile iron...

Use Inco's Nickel-Magnesium Additives—NMA #1 or NMSA #2

The most effective way to produce ductile iron* castings is to introduce the magnesium into your melts with a nickel carrier.

And it's easy when you use Inco's two high-density, quick-melting nickel-magnesium additives, developed specially for use in the production of ductile iron.

Advantages of using Inco's Additives in your melts

- two uniform sizes for easy addition — either 2¼ x ¾" or 1" x 8 mesh.
- higher magnesium retention than any non-nickel additives in both conventional and plunging methods of treatment.
- higher density reduces floating and burning at surface in conventional


treatment; requires smaller volume in bell in plunging treatment.

- higher pouring temperatures — sustains less temperature loss on treatment.
- increased tensile and yield strengths, improved wear-resistance in nickel-alloyed ductile iron.
- improved Ni-Resist** austenitic ductile iron castings.
- uniform and reproducible characteristics for each melt.
- greater control over casting production—reduction of costly rejects.

The table below shows the recommended Inco Additive to use in all commercially accepted types of ductile iron. For answers to your further questions on Inco's Nickel-Magne-

sium Additives, just contact your nearby Inco Field Section Office or your Inco Foundry Products Distributor.


*Ductile iron is produced by authorized foundries licensed under patents of The International Nickel Company, Inc.
**Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street  New York 5, N. Y.

NOMINAL COMPOSITION OF INCO ADDITIVES			
	NMA #1	NMSA #2	
Metal		13-16%	13-16%
Magnesium		26-33%	26-33%
Silicon		Balance	Balance
Nickel			
INCO ADDITIVE TO USE FOR VARIOUS DUCTILE IRONS			
Iron type	Recommended additive		
60-45-10	NMSA #2		
60-60-03	NMA #1 or NMSA #2		
100-70-03	NMA #1		
120-90-02	NMA #1		
Ni-Resist austenitic	NMA #1 or NMSA #2		

INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER



Pouring a 2000-lb. casting at ELECTRIC BOAT DIVISION, GENERAL DYNAMICS CORPORATION, Groton, Conn.

The U.S.S. GEORGE WASHINGTON,
America's first POLARIS-firing A-sub

RCI Core Binders

Used in precision castings for America's A-Subs

• Precision castings are critical pieces in ELECTRIC BOAT's gigantic A-sub production puzzle. Every phase of the project is tightly security-sealed. While it is no secret that a variety of A-sub valves, structural boxes, gear cases and other components, are poured — in aluminum-bronze, manganese-bronze, super-nickel and other metals — specifics are unavailable. One thing's for sure: castings must be perfect! And, it is reported that in operations where ELECTRIC BOAT is using RCI Core Binders, they find

that excellent results are obtained.

If you have a core binding problem, chances are RCI has already found the answer. Liquid phenolic, liquid amino and liquid oleoresinous core binding resins, liquid sand conditioners, liquid binders (self-curing), and liquid phenolic, powdered phenolic and granulated phenolic resins for shell coremaking and shell molding are all on the list of RCI Foundry Products. Let's talk about Reichhold resins in terms of *your* applications.

FOUNDREZ — Synthetic Resin Binders)
COROVIT — Self-Curing Binders
CORCIMENT — Core Oils
CO-RELEES — Sand Conditioning Agent
REICOTE — Sand Coating Agent

REICHHOLD FOUNDRY PRODUCTS

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.

*Creative Chemistry...
Your Partner in
Progress*



